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Senate documents

Bd.: [347.] 1882/83, Vol. 2 = Congress 47, Sess. 2

Washington, DC 1883
Am.b. 3040-347,2
urn:nbn:de:bvb:12-bsb11547873-6

Am. B.
3040
(347)

Proceedings

THE

EXECUTIVE DOCUMENTS

PRINTED BY ORDER OF THE

SENATE OF THE UNITED STATES

FOR THE

SECOND SESSION OF THE FORTY-SEVENTH CONGRESS,

1882-'83.

IN FIVE VOLUMES.

Volume 1.—Nos. 1 to 24, inclusive.
Volume 2.—Nos. 25 to 32, inclusive.
Volume 3.—Nos. 33 to 85, inclusive, except Nos. 77 and 84.
Volume 4.—No. 77.
Volume 5.—No. 84.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

0187

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TO

THE EXECUTIVE DOCUMENTS

OF THE

SENATE OF THE UNITED STATES

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47TH CONGRESS, 2d Session. } SENATE. { EX. DOC. No. 25.

LETTER

FROM THE

SECRETARY OF THE INTERIOR,

TRANSMITTING,

In response to Senate resolution of December 15, *information relating to industrial education in the United States.*

DECEMBER 27, 1882.—Referred to the Committee on Education and Labor and ordered to be printed.

DEPARTMENT OF THE INTERIOR,
Washington, December 27, 1882.

SIR: I have this day received from the Commissioner of Education, and have the honor to forward for the information of the Senate, the following reply to the resolution of the Senate of the 15th instant, calling for information in regard to industrial education.

Very respectfully, your obedient servant,

H. M. TELLER,
Secretary.

The PRESIDENT OF THE SENATE.

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION,
Washington, D. C., December 27, 1882.

SIR: I have the honor to acknowledge the receipt of the following resolution of the Senate of the United States, referred by you to me on December 19:

Resolved, That the Secretary of the Interior is directed to furnish to the Senate the latest and fullest information in the possession of the Bureau of Education in relation to technical or industrial education in the schools and colleges endowed in whole or in part by the Government of the United States, and also in other schools in the country reporting instruction in industry for either men or women.

Education, in its relation to industry, is a subject of earnest consideration in the public mind. Older countries, struggling with some of the severer problems of civilization, have found great aid in their solution by modifying the instruction given the children in their schools. Educated labor is found to be a prominent factor in national prosperity.

Recently industrial education in some form has been the subject of special inquiry in various foreign countries. Several of our own States,

and a number of associations and institutions, have been making active efforts to gain further information upon the subject.

This office is compelled to make technical instruction a subject in regard to which it constantly collects and communicates facts; and I have the honor to submit the following reply to the resolution of the Senate, drawn from material already gathered in the office in response to previous demands.

I have the honor to be, very respectfully, your obedient servant,

JOHN EATON,
Commissioner.

The Hon. SECRETARY OF THE INTERIOR.

REPORT.

It will be seen that the information called for by the Senate resolution is concerned with a wide educational field. Colleges of agriculture and mechanics, and institutions affording instruction similar to that of agricultural colleges, as well as those which give opportunities to women for industrial education, come within the sphere of inquiry. In other words, the educational training of the farmer, the mechanic, and the housekeeper, so far as it is attempted by organized effort, is the subject on which information is required to be given. In the West provision is usually made for the education of these three classes in the same schools; for, in the newer States, it is the generally accepted belief that those who are to be coworkers in actual life may well be associated in the preparation for it; that man and woman are entitled to equal and similar, if not identical, educational privileges. In the more conservative regions of the East and South the sexes are not so frequently educated together.

In Massachusetts the colleges of agriculture and mechanic arts are distinct from each other, so that not only the education of the housekeeper is entirely separated from that of the farmer and mechanic, but even these latter classes are trained in independent institutions. This separation exists to a less extent in Missouri, where the school of mines and metallurgy is distinct from the other departments of the university.

It has been necessary, in order to cover the entire ground contemplated by the resolution, to extend the report beyond the limits of a single class of schools, and to present information respecting varied institutions other than those endowed by the national land grant. The colleges of agriculture and the mechanic arts are entitled to and receive the most prominent place in both resolution and report for many just reasons. They are doing a great proportion of the work of industrial education. The number of students attending them in 1880 was more than double that of the students in the schools of science not aided by the land grant, if the institutes affording only evening instruction, special teaching, or general lectures, such as the Cooper Institute of New York and the Wagner Institute of Philadelphia, be excluded. It is true that some of these individual schools of science are munificently endowed, and afford their students most excellent opportunities for obtaining a technical education, but this has come to be true of some of the schools, colleges, and universities which have received national aid, and many of those that are less richly endowed are occupying fields which otherwise would be destitute of institutions for educating men in the practical sciences and arts, and consequently without educated men to foster and direct their industries and utilize their resources. As the fruits of these institutions appear, they show that in all sections the education of persons to be engaged in staple industries is being obtained largely within their walls.

It is evident [said an eminent educator after an extended tour among our agricultural colleges] that the American technical colleges are rapidly taking the idea that their usefulness will depend, not on solving an abstract problem as to what sort of

education would most benefit a farmer, for example, but on solving a problem much more practical, though really harder, namely, what sort of an education does the farmer want or can be induced to receive in order to fit him for his work of farming.

The thinking farmer and mechanic have wanted and will ever desire to see a system of schools established and in operation for the benefit of the classes to which they belong. The farmer, striving to improve his land and crops and stock, asks himself a thousand questions, and is obliged to confess his inability to answer half of them satisfactorily. There is a latent, deeply-rooted belief in his mind that it is possible that his son may be so taught as to know not only the innumerable details and the practical working of the farm, where he himself is the best teacher, but also the things which have been beyond his comprehension. The peculiarities of soils, the causes of deficiencies in crops, the insects that injure them, the unproductiveness of his orchards, the diseases of his stock, the inconveniences of his buildings, these and similar things attract his attention, give rise to questions which he knows not how to answer correctly, and fix in his mind the thought that if education is education it can and should teach how to avoid or remedy the evils which are robbing him of his profits and impairing his prosperity. There are also those who take a more comprehensive and far-reaching view of the subject. They remember that agriculture feeds the world and gives employment to a multitude of its inhabitants; that it is an art founded on science, and that as the departments of science on which it is based are more thoroughly known, and the art itself is carried to greater perfection, the world will be better fed and the services of those that till the earth more richly rewarded. They regret that agriculture is slow to advance. Oldest of the arts, it is almost last to come into deserved prominence, and to receive systematic and liberal encouragement and aid.

This lack of adequate development [says a recent writer] is due to two main causes: To the rarity of scientific investigation into the principles upon which the tilling of the ground (and the care of cattle) ought to be carried out, *i. e.*, into the laws governing the growth of crops and of beasts, and to the want of adequate scientific training on the part of the farmer. If we look at the other arts, we shall find the numbers of the respective guilds enthusiastically bent on two things: On the advancement of scientific inquiry and the scientific education of the practitioner. * * * Of all human occupations, the one which most of all stands in daily need of a sound scientific judgment and of wide scientific knowledge, is that of tilling the ground and feeding cattle. The problems of agriculture are scientific problems of the highest difficulty and complexity. The question how, under given conditions, to feed a beast in the cheapest and best way is one which involves the most profound physiological considerations; is one which can only be satisfactorily answered by prolonged and exact experimental inquiries. The adequate preparation of the ground for the growth of a given crop is a subject which, seriously examined, expands into a whole series of problems, taxing to the utmost the fullest and most advanced chemical and botanical knowledge.

An idea prevails with the mechanics similar to that entertained by the individual farmer. He, too, sees in a suitable education the advancement of his position and the elevation of his children. A proof of this is furnished by the answers given by employés in various kinds of factories and shops to questions concerning education, asked of them by the New Jersey Bureau of Statistics of Labor and Industries. A laborer in a glass factory writes: "Technical education should be made compulsory for the laboring class." A silk worker says: "Industrial schools as they exist in Europe should be set up." A carpenter believes that "There should be appropriations for technical schools in every city." The idea of education for business and for labor penetrates, pervades, and permeates the masses. It has compelled recognition in political

circles, and statesmen have sought means whereby it might be satisfied. To use the words of President White, of Cornell University :

> It is not to be scolded out of existence by solid review articles or pooh-poohed out of existence by pleasant magazine articles. Evidently the idea is rooted in our planet and will hardly be pulled up by narrow literary men who hold the time-honored studies the most eminently respectable; or by narrow practical men who disbelieve in "book learning"; or by narrow religious men who fear that geology may harm Genesis.

It was in conformity to this practical, popular, and controlling idea of educating men for their work that colleges of agriculture and the mechanic arts were established, and are arranging and putting into operation their courses of study, training, and experimentation ; and whatis being done to satisfy a popular educational demand should be plainly set before the people, that they may know that their wishes are regarded and their expenditure in this direction is applied for their own benefit.

Again, the colleges of agriculture and mechanic arts deserve prominence in a report of this kind because they are distinctively American. No other country possesses a similar class of institutions, which freely open their doors to the youth of the regions in which they are situated and provide for their students wise, liberal, and appropriate courses of study adjusted to their peculiar wants. Nowhere else is there a system of schools affording parallel lines of instruction, doing the same kinds of work, and covering so wide a ground. The countries of Europe have their schools of agriculture and of polytechnics, but they are more specialized than ours. Education is not so much directed toward preparation for citizenship in the monarchical governments of Europe as with us. There the end of teaching has been reached when it has produced a skilled specialist in some branch of science, art, or industry ; here the work to be done by the pupil is not taught to the exclusion of his social and political obligations. Our system of agricultural colleges recognizes the fact that the American laborer has duties to perform, both as a workman and as a ruler. They seek to educate him for leading industries, so that our fields may be carefully tilled and our trades skillfully followed. They aim, also, to prepare him by a general education for his share in the government of the people, so that the prosperity and intelligence of the nation may be increased through his efforts.

The agricultural and mechanical colleges of the United States not only differ as a class from foreign schools in being less specialized, but are also dissimilar to the schools of particular nations and to individual schools in many points of detail. They differ from the agricultural colleges of England in being open to all youth ; while at Cirencester, where the tuition is £50 per annum, and presumably at its sister agricultural college, Wilts and Hantz, only the sons of the wealthy are educated. They are unlike the agricultural colleges at Altnarp, Sweden, and at Hohenheim, Wiirttemberg, for in those the sons of the wealthy and titled receive other instruction than that given to the sons of peasants. "Every great agricultural college in Europe," says President White, "must either be cut into two parts, with peasants' sons in one and the gentry in the other, as at Hohenheim, or they must exclude peasants' sons altogether, as at Cirencester." Our colleges are not in name a part of a graded system of schools teaching the same subjects like those of Ireland, nor even links in a chain of institutions laboring for the same ends, like those for agricultural education in Sweden. In that country the agricultural colleges are aided in their work by agricultural schools, model and experimental dairies, and agricultural societies. In Ireland there is a graduated system of instruction from the public schools, in which a text

book on agriculture is used, to the farm schools, and finally to the Albert Institute at Glasnevin. In France there are farm schools, departmental schools of agriculture, and a national agricultural institute.

Elsewhere there is a similar classification of schools. Our agricultural colleges are not a part of a system of agricultural schools. To be most useful they must be connected with some tributary institutions. The public schools are the only available ones with which to make connection, and this connection is being made close and firm, and by it agricultural colleges are becoming a part of the national system of education. This intimate relation of our higher institutions with public schools is illustrated by a law passed by the legislature of Minnesota, by which it binds its high schools closely to its university, which receives the benefit of the land grant of 1862. Aid is provided for them by the State; in order that it may be bestowed judiciously, its distribution is intrusted to a board of commissioners, one of whom is the president of the university. They must require each school desiring aid to comply with the following conditions:

1. That there be regular and orderly courses of study embracing all the branches prerequisite for admission to the collegiate department of the University of Minnesota.

2. That the said schools receiving pecuniary aid under this act shall at all times permit the said board of commissioners, or any of them, to visit and examine the classes pursuing the said preparatory courses.

After inspection, report, and approval, each school receives $400. The president of the university has charge of the required examinations when a study in a college preparatory course is about to be completed. Examination papers are furnished by the examining officer of the board, and every pupil that passes the examination receives through his principal a certificate on which is the following indorsement: "On applying for admission to the University of Minnesota, present this certificate and you will be excused from examination in the study named."

There are colleges of agriculture in Europe giving instruction in more advanced studies and requiring greater previous training than do any of the colleges of the United States. A single illustration will suffice. In Bavaria higher agricultural education is afforded by the central school, at Weihenstephan, and the agricultural department of the polytechnic school at Munich. The candidate for admission to the central school must complete the course of study either of the Gewerbeschule or the Realgymnasium. The student from the former school has carefully studied his mother tongue; mathematics, including trigonometry and descriptive geometry; the natural sciences, especially chemistry and zoölogy; the French language; and all the usual studies of an elementary course, such as drawing, arithmetic, geography, and history. The student coming from the Realgymnasium has pursued similar studies, except that he has not obtained an actual knowledge of the sciences, but has studied Latin seven years. In either case the applicant for admission to the central school must have a practical acquaintance with farm work. The course of study in this school is such as to require this amount of preparation. Applicants for admission at Munich must spend two years more at their books, though they are not required to have a practical knowledge of farm operations. These requirements for admission are equivalent to the completion of an ordinary collegiate course, and the studies pursued are on a par with a graduate professional course.

In touching upon other differences between American and foreign technical schools, I cannot do better than to quote the language used

by Prof. John D. Runkle, in an account of some institutions with which he became familiar during a recent visit to Europe:

> The teaching force in all of them, particularly in the professional subjects, is much larger than with us. The result is that there is a much greater subdivision of subjects, and more time given to each. The theoretical subjects are treated with much more fullness than is possible here, and a much wider range of instruction is included in each department.
>
> There is also a marked contrast in the methods of instruction. In the foreign schools all the instruction is given by lectures, and the professor, as a rule, takes no means to learn whether his students understand the subject or not. They are expected to take sufficiently full notes during the lecture to be able afterwards to write it out fully. For those students who have the ability and industry to do this work faithfully the method is a good one; but from all the information I have been able to gain, with a large number it fails. While most of the programmes of instruction refer to periodic examinations for testing the student's progress and proficiency, I know that in some of the German schools such examinations are entirely discontinued, and the only examinations held are those for degrees. The reason given me was that it entailed too much work upon the teachers.
>
> Another strong contrast between these schools and those at home is in the freedom of the student in the choice of studies. There the student enters his name for certain courses of lectures, and then attends or not, as he likes. Of all the polytechnic schools we have visited, that at Zürich is the only one which prescribes a fixed course of studies and holds stated test examinations for progress and promotion; and even in this school the agitation has begun for the adoption of the German method. The great advantage to the student of the German freedom is that it enables him to concentrate all his time and energies upon those studies which are vital to the end he has in view. This course is only allowable after the student has acquired a good general education, equivalent to the under-graduate course in the best American colleges and technical schools, which I consider a far broader and more substantial education for the mass of students than that furnished by the German schools of the same grade. It may be that the German student enters the polytechnic school with technically a better preparation than the majority of our students; but this by no means justifies the removal of all further restraints in the manner and matter of the subsequent education. Even the best students are aided by the moral support of frequent examinations and a fixed course of studies until they are able to work with a good degree of independence, and only need the guidance and advice of teachers in connection with proper opportunities. After the student has the ground-work of his profession laid he can profit by a period of freedom to fill out the plan and make up deficiencies of which he will then begin to be conscious.

A final reason for devoting the larger part of the report to the colleges of agriculture and the mechanic arts is that they have been given endowment funds by Congress; those who have received money from the government should furnish reports of the methods and results of its expenditure. This duty was required in the act granting aid to agricultural colleges in the following words:

> An annual report shall be made regarding the progress of each college, recording any improvements and experiments made, with their cost and results, and such other matters, including State industrial and economical statistics, as may be supposed useful.

SECTION 1.

COLLEGES OF AGRICULTURE AND THE MECHANIC ARTS.

Many of the colleges of agriculture and mechanics made full and satisfactory replies to a circular letter addressed them some time since for the purpose of obtaining direct statements about their educational aims, methods, and appliances. Where these statements were incomplete they were filled out from material in this office, such as catalogues and annual reports. In the absence of any special statement from a college officer, facts have been gleaned from available sources. In this way a brief sketch of each institution has been prepared, and is presented, usually after revision by the head of the institution it describes,

in Appendix A, accompanying this report. In Appendix B are statistics of the same institutions.

There remains, therefore, little to be said concerning agricultural colleges except in the way of a general review of their sphere and work.

OBJECTS.—The usual form of stating the objects these colleges are endeavoring to accomplish is to say that they are those specified in the act of Congress of July 2, 1862, by which the grant of land for the endowment of these institutions was made. This act says:

> The leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.

The real intent of the act has been considered to be not only the establishment of schools for professional training in agriculture and in trade, but particularly "to promote the liberal and practical education of the industrial classes."

1. Education which prepares persons for the occupation they are to follow is practical. The instruction of the dissecting room and that of the lecture room are equally practical to the medical student. The instruction of a young mechanic in arithmetic and in reading is as much a part of his practical education as his labor in the shop beneath the eye of a master. The former kind of instruction is everywhere afforded in our public schools; the latter is not provided for the multitude of laboring men. With the disappearance of apprenticeship and the multiplication of artistic manufactures has come a great need of training for mechanics, but no direct way has been opened by which they can learn their trades. The truth of this statement is shown by the answers given by New Jersey workmen of different trades to the question "Is there any system of teaching apprentices in the factory where you work?" which had been asked by the statistical bureau of that State.

Glass-blowers.—"None."

Iron workers, iron moulders.—"Very loose system; taken without indenture, and are discharged at their own pleasure or that of the employer, with the trade only half learned." "They work at what they can do and gradually learn." "Pick it up the best way they can." "If they are smart boys we teach them." "They are not indentured; a verbal agreement is all." "Take them for five or six years, paying them at first $2.50 a week."

Core-makers.—"No one teaches them; they work up themselves." "Merely verbal agreement, which is not often regarded." "If they have ability and aptness anyone is willing to teach them." "Learners must serve a term of two years."

Nail feeders.—"The system is to keep one from learning the trade." "They give us no chance to."

Iron roller.—"They work up."

Saw maker.—"Yes. Hire them by the week, with the understanding that if they are steady they will have the first chance to learn. The time thus occupied is allowed if they are taken on."

Printers.—"Boys are taken on a three years' apprenticeship, and are taught the trade by the foreman." "Go in as a 'devil' and work up." "It has been successfully taught in technical schools."

Weavers in cotton factory.—"Weavers take new hands for about three weeks, after which they become spare hands until they are good weavers and work for themselves. They receive nothing while learning." "Taught to fix looms; go under instructors for two or three weeks."

Woolen mills operatives.—Weaver: "Learn by practice in a few weeks, with an old weaver." Wool sorter: "Yes, there is a regular system. We set the apprentice to work assorting until he can, in a measure, tell the qualities. It is all eye practice."

Carriage makers.—"Work them up gradually." "Generally they are taken during the busy part of the season and then sent off." "A cut-throat plan."

Chair makers.—"The boys are used to the best advantage of the employer. The work is so subdivided that a boy cannot learn how to make a complete chair in four years."

Potter.—"The foreman teaches them." "They are taught by being shown." "They learn by watching and being instructed in the different branches."

Silk weavers.—"Yes. Apprentices are taken and sent to some experienced hand for three or four weeks to help and get instructions. This is without pay. Then they obtain looms for themselves." "Yes and no. The weaver is at liberty to take in apprentices whenever he chooses. As soon as they are able to tend a power loom they can fill vacancies, if there are any." "The employés ought to have control of the apprentices, in order that the bosses may not take their friends and favorites to teach them the trade, and send off those of the employés." "Learners must stand by and look on for three or four weeks without pay, until they can weave." "Take children under 14 years and let them learn for one or two weeks." "Sometimes they are taught. In order to understand perfectly they must work for six weeks. They work three out of the six without pay."

Silk workers.—"School girls are taken for three or four weeks, until they understand how to tend six or twelve ends; till they are able to run a machine." "Experienced silk workers are instructed little by little, until finally they are able to twist perfectly." "Girls taken in learn how to handle silk and start the machine." "Boys are taken on small wages to help, and in course of time become skilled workmen." "The method here adopted is to take in fresh hands, let them look on for a week or less, then help one or two weeks without pay, and then discharge them. If they desire to come back they are taken from $3 to $5 a week." "There are not sufficient opportunities offered to the girls to learn the other branches of the business."

Jewellers.—"Boys come in at low wages and work up until twenty-one." "No system; they learn all they can." "During a period of from three to five years, until he knows how to scroll." "Boys are placed between men and sometimes put on the same jobs, and are watched by them." "Almost every shop has its own system, and the majority a very bad one. The trouble is that our trade is not sufficiently organized to compel employers to have a fair plan of taking in boys. In a good many shops most of the work is done by teams of boys or green hands. Thiis is the curse of our trade and keeps us down." "To get all the work possible out of the apprentices, so that the journeymen will lose all the time possible, is the only method in my shop."

The educational opportunities of an apprentice at the present time compared with those he possessed in the days when apprenticeship was the accepted way of admission to trades and had the protection and support of wise laws are discouraging. This is well illustrated by an extract which Mr. Twining gives in his Technical Training from a writer on technical education in France, from which I take the following:

The old guilds, with their antiquated rules and rage for public banqueting, were not perhaps progressive bodies; but in their own rough way they kept an eye on apprentices, reproved and even punished the masters who were remiss in instructing them, and maintained among the apprentices themselves a wholesome emulation by means of frequent examinations, badges, and money prizes. There were, in fact, trade degrees like those in a university; and an apprentice, however rich he might be, could only become a master and set up shop after having obtained three certificates of proficiency. The first was bestowed after two years of apprenticeship; the second, with a colored badge, at the end of the fifth year; and the third, with a silver badge, when the apprenticeship was concluded in a brilliant manner. * * * In the guild times care was taken that every tradesman who accepted apprentices should be thoroughly qualified to teach them. Nowadays, no qualifications being needed, it is naturally the most incapable tradesmen who are keenest in trying to secure apprentices by low premiums. They take in a boy as pupil and treat him as a servant, send him out to carry parcels, make him sweep the shop, wash up plates and dishes, and let him pick up many more bad habits than good lessons.

The reasons for the decay of apprenticeship are numerous and many of them of long standing. Among objections advanced by Adam Smith and his school to the system are interference with the property which every man has in his own labor, encroachment on the liberties of employer and employé, restraint of competition, unnecessary duration, and its failure to allow the rewards of faithful labor to be enjoyed as they are earned. Mr. Stetson, in his work on technical education, says:

> This decay of apprenticeship is mainly due to the subdivision of labor which is now observed in the manufacture of nearly all things, from pins to locomotives, because it is found to yield the best results. The use of machinery, the character of which is often such as to put an end to small enterprises, has promoted this subdivision by accumulating workmen in large groups. The beginner, confining himself to one department, is soon able to earn wages. This gratifies both himself and his parents; and so he usually continues as he began.

Now that apprenticeship is actually gone, the question of the practical education of the industrial classes in their handicrafts and occupations is more than ever one for the public consideration. There is no prospect of a revival of old-time apprenticeship. Foreign skilled labor ought not to be made a reliance. Our own youth ought to be, and must be, trained to occupy leading places in the arts and manufactures, by means of special instruction given in schools organized for the purpose. Any system of schools or instruction which fits pupils to enter intelligently upon the duties of life and the work of a trade promotes the practical education of the industrial classes.

Occasionally some form of apprenticeship is devised by a single firm, or by an association of manufacturers or mechanics, by which workmen may be prepared for places in which they need more than ordinary skill. An illustration of this is found in an attempt made a few years since by a firm in Springfield, Mass., to obtain and discipline such a force of mechanics as they needed in their work as designers and manufacturers of machinery. Applicants were to be at least sixteen years old. The term of apprenticeship was six years for those under twenty who had had no previous experience, and five years for those over twenty. Those who had worked in a shop were advanced according to proficiency. Fifty-eight hours a week of work in the shop and nine hours of evening study were required. The rates of pay for labor varied from five to thirteen cents an hour, depending upon age and length of service. Two cents an hour additional were paid into a reserve fund and kept for the apprentice until he had finished his term of work. Then it would amount to some $400. This scheme of apprenticeship promised success, but the firm were compelled by business changes to dissolve partnership, and so the plan was abandoned.

The necessity of industrial training to the advance of individuals and the prosperity of a nation has been well shown by Mr. J. S. Russell.* An abstract of portions of his work will show vividly the real objects for which technical schools are being established, and for which the institutions endowed with the national land grant ought to labor as their circumstances will permit.

The mission of the book was to stir up a crusade against educational ignorance, disorganization, and neglect. "It was written under the conviction that the power, wealth, influence, and moral character of the English people were dependent on systematic, elementary, scientific, and technical education." The earlier parts of the work are devoted to a description of the organization by which the best educated nations of the continent have reached their present distinction. After a few chapters the author comes to the consideration of technical education as a national want. It interests a man in the work done by himself and his neighbor. It makes workmen better, both in themselves and as aids to each other.

> An intelligent community of workmen will get through their work quicker, will fit its parts more nicely, will finish off everything more sharply, will waste less material by trial and error, and so give higher value as well as quality and durability to all their work, than ignorant, unrefined, ill-educated men.
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> The highest value in the world's markets will be obtained by that nation which has been at most pains to cultivate the intelligence of its people generally, and afterwards to give each the highest education and training in this special calling.

These propositions axiomatic to his mind are sustained by the lessons of the world's improvement as shown by expositions, in each of which the nations which had educated their mechanics excelled those which had not. Quotations are given from officials and workmen who attended the Paris Exposition of 1867. A china painter says:

> The present prosperity of this country is so unmistakably interwoven with its manufactures, and the pre-eminence of these depends so much upon new adaptations, discoveries, and improvements, as to demand for the workers in iron, china, and other departments the readiest and best educational training and enlightenment this nation can give them.

Others speak in the same manner.

The technical education of the industrial classes has also social and moral effects, drawing master and workman into closer and more sympathetic relations, and inducing each to aim at good work rather than mere pecuniary success.

> When education has given to each man a knowledge of all the branches of his work, and there remains no difference of rank, excepting superior skill and intelligence, then each man's individual work will be weighed in the balance, and the true share of his merit will be appraised in the scale of wages.
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> Equality will be then, as now, impossible, but the scale of each man's life may be be one of steady, continual, meritorious rise.

After a few chapters on English and continental education the author discusses the kinds of technical training which various industrial classes require, in addition to a fundamental education, saying substantially:

> The farmer should be educated in sciences, elementary engineering, mechanics, and agriculture; the miner, in mineralogy, geology, chemistry, and his own work; the merchant, in geography, history, foreign languages, political economy, and laws. The machinist must master all the known powers of material nature: heat and cold, weight and impulse, matter in all conditions—liquid, solid, and gaseous, standing or running, condensed or rare, adamantine or plastic—all must be seen through and comprehended by the master of modern mechanics. Architects, engineers, teachers,

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*Systematic Technical Education for the English People, by J. Scott Russell, esq., M. A., F. R. S. London, 1869.

and all classes of workers require technical education, which is defined to be "that special training which renders the talents of the educated man directly useful to that society in which its youthful member is destined to pass his life."

The details of a proposed technical university, and other matters pertaining to the application of general principles rather than the discussion of the principles themselves, occupy much of the latter portion of the work. In one chapter, nevertheless, the author makes general remarks on the *present* need of technical education, summarized as follows:

> The world is now the field in which men must compete. Therefore they ought to know its languages, that they may go from one country to another as better opportunities for them to labor are offered. They should be acquainted with its manufactures and markets, that they may be successful in competition with home producers and foreign importers. The proper education of mechanics enables them to dispense with the services of expensive agents and middlemen and to adapt themselves to the changes and progress in industries. In this progress agriculture is becoming chemistry; husbandry, machinery. All that is done without skill is going to be done, not by intelligent men, but by dead machinery. Yet intelligent, educated, conscientious men are needed to invent and manage this machinery. For the time when such men are required in every occupation the working man should be fitted. But above and over him will arise the class who, in their turn, are to instruct, guide, and think for him. However skilled to work his machine, he will still depend on a superior to invent or make it; on a man who shall come after him to complete it. These are the higher departments which form the higher ranks of crafts; in short, above the skilled doers we must have the skilled thinkers. * * *
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> In this view of an intelligent, skilled nation it is plain that we shall be able to do without the unskilled, the unintelligent, the uneducated. * * * The men of the future must have one of two qualifications: skill to do, education to know, or both.

Conclusions as to the value of technical education have been drawn by Mr. C. B. Stetson from the opinions of manufacturers, mechanics, educators, and statesmen. They are stated in a concise and comprehensive form in his work already referred to, and deserve the consideration of all thinkers upon the subject. They are as follows:

> (1) The person who has general charge of any business should understand that business both theoretically and practically. His knowledge of principles should be such as to enable him to instruct any subordinate requiring instruction, to determine at once the comparative value of different processes of work, or to invent new ones when emergencies require it. In a word he should be able to reach just conclusions at once by his knowledge of principles, and not slowly by trial and error. He should be workman enough to know when work is well done that he may not be cheated by those under him, and that he may be able to render justice unto all by duly discriminating between the skilled and unskilled laborer. He should understand his business as a whole, and the relation of each part to the whole. Neither skilled workmen nor tariffs can compensate for stupidity on the part of the superintendent. Only the very few exceptional geniuses, like Stephenson, become thus qualified to take charge of enterprises, great or small, without special school instruction.
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> (2) The workman should not only be dexterous in manipulation, he should certainly know so much of the theory of his business as will enable him readily to comprehend all instructions, verbal or graphic, given for his guidance. The more extended and thorough his knowledge of principles the better. Such a workman requires very little supervision; he executes with rapidity; he wastes the least possible; he adapts himself readily to new methods; he devises novel and better ways for doing even the simplest things; he is the first to be promoted; he is the last to be discharged; he always commands the best wages, and yet his labor is the cheapest in the market. On the other hand the workman who works only by "rule of thumb," though he may be dexterous, lacks logic, lacks invention, lacks adaptability; indeed, is only a better kind of machine.
>
> (3) The workman should be better instructed because of the machinery used, since it is the rude or dexterous workman rather than the really skilled workman, who is supplanted by machinery. Skilled labor requires thinking, but a machine never thinks, never judges, never discriminates. Objects which have a simple and regular form and require high finish or not, may be made with advantage by machinery if the objects are produced in large numbers. Most kinds of work which demand little besides strength for their execution can usually be best done by machinery too. Though the employment of machinery does, indeed, enable rude laborers to do many things now which formerly could be done only by dexterous workmen, yet, after making allowance for all the bearings of the question, it is clear that the use of machinery has decidedly increased the relative demand for skilled labor as compared

with unskilled labor, and there is abundant room for an additional increase, if it is true, as declared by the most eminent authority, that the power now expended can be readily made to yield three or four times its present results, and ultimately ten or twenty times, when masters and workmen can be had with sufficient intelligence and skill for the direction and manipulation of the tools and machinery that would be invented.

(4) All those persons whose business it is to produce new combinations of matter—such as the farmer, miner, dyer, bleacher, founder, maker of machinery, and numerous others—should have a knowledge of chemistry. Without such knowledge, which is an essential element of skilled labor in these departments of industry, neither rude nor dexterous labor can produce satisfactory results.

(5) The utmost effort should be made to produce articles of beautiful design, whether in form or in color, or both. The difference between good design and poor design is the difference between success and failure in the market of the world. When the beauty of the object depends, as it usually does, upon its own form, or upon the form of the applied decoration, the workman should be one who has been thoroughly instructed in artistic drawing and designing. Not only should the originator of the design have been thus instructed, but also the reproducer of the design in wood, metal, earth, or other substance.

(6) For the most successful prosecution of any great enterprise in land or naval architecture, in the construction of railroads, canals, machinery, there should not only be an abundance of thorough and expert draughtsmen, but each workman should be draughtsman enough to make a drawing of any object he is required to construct.

Of two competing establishments, the one having such workmen, the other not, the former would not only win, but would distance the latter every time.

Says President E. P. Tenney, of Colorado College:

The means for industrial education will certainly prove a part of the endowment of any well-ordered college in the new West. It is essential for aiding needy students, for promoting a manly independence, for training those who will develop the material interests of the country, and for preparing young men to induct semi-barbarous populations into the mysteries of civilized life.

2. It was not an easy question to determine the best mode of placing the benefits of the endowment fund provided by the nation within reach of the people for whom it was designed. Should the money be granted to existing institutions or made the basis of establishing new ones? Should the courses of study be closely confined to the wants of the artisan or enlarged by studies more purely disciplinary? Should agriculture or mechanics predominate?

The industries of each State, the wealth of its inhabitants, and their sentiments with regard to education determined largely the solution of these problems. In California and Missouri, States abounding in mineral resources, there are courses in mining and metallurgy provided in the institutions receiving national aid. In manufacturing States, the colleges have generally lent their aid to the prevailing interests.[1]

In the manufacturing State of Pennsylvania the institution receiving the national endowment is chiefly agricultural, and it is in the farming region of that State. In the great grain-producing sections of the Mississippi Valley, the colleges are rarely devoted principally to agriculture. It does not require skill to obtain remunerative crops from the rich prairies; and it is in the States where the soil is less fertile by nature and more impoverished, the climate less favorable, and the rural population more dense, that the need of scientific agriculture is felt. In accordance with this rule, good types of agricultural schools are found in the

[1] A college which leans strongly toward some form of industry that does not attract the intelligence and wealth of the section of country from which it would naturally draw its students, will meet with opposition or negligence that will impair its usefulness and possibly end its existence. Maryland is largely a commercial State. One-third of its population is in the single city of Baltimore. The drift of the State is toward the commerce and manufactures of that city, and the president of its agricultural college, an institution where peculiarly ample facilities for the study of agriculture have been offered, has been compelled to confess that "few fathers desire their sons to become farmers."

cold and forbidding climate of Maine, on the exhausted soil of Virginia, and in the thickly-populated State of Massachusetts. This same influence is readily perceived in the distribution of agricultural schools in European nations. Those of Russia are found rather in its cold northern sections than its southern grain-producing areas. The wealth of the English land-owners and the poverty of Irish farmers find expression in the schools established for their education, those of England being few, expensive, and exclusive, and those of Ireland numerous, public, and elementary.

The wealth of States affects the character of all their institutions of learning. When the procuring of the bare necessities of life engrosses the attention of the people, only the most elementary forms of education are possible for their children. The Southern States, from which the tide of war swept not only wealth but the producers of wealth, cannot largely use, much less sustain, such expensive, advanced, and specialized institutions as the circumstances of the North permit and require. The frontiersmen must have schools more elementary and more industrial in their nature than those of the cities and villages in the East. In accordance with this principle it is found that all of the institutions aided by the land grant in the Southern States, with two exceptions, have preparatory departments, or else require for admission proficiency in those studies only which are pursued in the public schools. Several of them also have normal departments. The characteristic feature of the schools of Kansas and Iowa is the prominence given to industries. The wealth of the patrons of agricultural colleges has also largely determined the place which manual labor occupies in them.

The sentiments prevalent in a State with reference to education have greatly influenced the legislatures in determining the objects for which the money intrusted to them for disposition by Congress should be expended. The States of the West had cherished the idea of building up within their borders universities which should be centers of learning. By their creation was realized what Mr. Cushing once called "a noble and beautiful idea of providing wise institutions for the unborn millions of the West, of anticipating their good by a sort of parental providence, and of associating together the social and territorial development of the people." Upon the title page of the register of an institution of this class is the following quotation:

> One university, at least, should stand like a pillar of light in every State, the glory of the community and the constant object of its care, on which the watchful eyes of the State should be ever set, and to which its hand of bounty should always be extended. Bounty we have said, with all carefulness, instead of patronage; for such an institution patronizes the State far more than the State can patronize it.

For the establishment of these universities lands were set apart while the States were as yet only prospective Territories, and donations of money were made as needed. After the first establishment of the university almost yearly appropriations were made to it from the State treasury. The action of the legislature expressed the prevalent belief that the State university was the educational institution most needed, most beneficial, and therefore most worthy of public benefactions. It was in keeping with this idea that the fund placed at the disposal of the legislature should be turned in many cases toward the State university. Other arguments were not wanting. The general intelligence and elevation of the people is the most practical end of education. He who has learned to think has the key to success even in the industries; for thought can fertilize farms, produce beautiful fabrics, and give perfectness to every species of handiwork. To increase intelligence and nourish the power of thought is a burden which the university under-

takes to bear in the education of the masses; therefore it should receive the funds donated for that purpose. Again, the university is an existing institution. It has buildings and apparatus especially designed for educational purposes. It has a corp of trained teachers. Consequently it can best promote the objects contemplated by Congress when it gave of the public domain for educational purposes. The real reason why the fund arising from the national land grant was in so many cases given to existing institutions was the belief that they were doing the work most valuable to the people, and that the attainment of the results they were accomplishing was the virtual object for which the aid was given rather than the compulsory establishment of schools for which the people were not prepared and of which the people might be suspicious. Whether this belief was sound or not is for individual judgment. It was not universal. Those believing in special training for a particular occupation were not lacking in strong arguments, and these had the letter of the Congressional act on their side. For such training separate institutions were required. The atmosphere of classical education was not congenial to this practical work. Mental discipline would be pitted against manual skill, theory against practice, culture against knowledge. In short, those who believed in the possibility of a special training for the common industries saw the necessity of providing institutions which could carry out the new and growing idea untrammelled by the antagonistic tendencies of classical education. A compromise between the two parties was in some cases effected. But where the champions of industrial training, pure and simple, prevailed, the institutions receiving the national aid had one dominating object, namely, the education of those engaged in agriculture or manufactures. In the education of the former class have been attempted (1) the education of young men who were inclined to agricultural pursuits; (2) the enlightenment of the community on agricultural subjects by means of lectures, written articles, and experiments; and (3) the establishment of a clearing house for agricultural information. The aid rendered to those pursuing the mechanic arts has been practically confined to the training of young persons in the leading branches of industry and in the principles underlying all of them. And the arts of the household, not being wholly unlike or less important than these, obtained in many schools a just recognition.

The Kansas State Agricultural College proposes to carry out the objects of its endowment in the following ways:

First. It teaches the sciences applied to the various industries of farm, shops, and home. Chemistry, botany, entomology, zoölogy, and mechanics are made prominent means of education to quick observation and accurate judgment. Careful study of the minerals, plants, and animals themselves illustrates and fixes the daily lesson. At the same time, lessons in agriculture and horticulture show the true applications of science.

Second. It gives a substantial education to men and women, among farmers and artisans, and in business life. Such general information and discipline of mind and character as help to make intelligent and useful citizens are offered in all its departments.

Third. It trains in the elements of the arts themselves, and imparts such skill as makes the hands ready instruments of thoughtful brains. The drill of the shop, garden, and farm is made a part of the general education to usefulness, and insures a means of living to all who make good use of it. At the same time, it preserves habits of industry and manual exertion and cultivates a taste for rural and domestic pursuits.

Fourth. It strives to increase our experimental knowledge of agriculture and horticulture. So far as means and circumstances permit, experiments are undertaken with a view to more definite results than ordinary experiments can give. At the same time, the students themselves are trained to a more accurate observation and judgment in such practical tests of principles in farming.

Fifth. It seeks to disseminate such practical truths as have stood the test of scien-

tific inquiry. For this purpose it publishes the weekly *Industrialist;* and its officers share in the debates and consultations of farmers and horticulturists throughout the State.

Funds.—The principal source from which our colleges of agriculture and the mechanic arts derive an income is the endowment resulting from the land grant of 1862. Some colleges have received large appropriations from their States and munificent gifts from individuals. The amount of land given and the sum of money realized from it appears as follows in The Public Domain, by Thomas Donaldson:

Name and location of institution.	Amount derived from sale of United States land or scrip.	Number of acres received from the United States in land in place, or scrip in lieu, by the several States.
Agricultural and Mechanical College of Alabama, Auburn, Ala	$216,000	240,000, scrip.
Arkansas Industrial University, Fayetteville, Ark	135,000	150,000, scrip.
University of California, Berkeley, Cal	750,000	150,000, place.
Agricultural College of Colorado, Fort Collins, Colo *a*	.....	90,000, place.
Sheffield Scientific School of Yale College, New Haven, Conn	135,000	180,000, scrip.
Delaware College, Newark, Del	83,000	90,000, scrip.
State Agricultural College, Eau Gallie, Fla. (location questionable; college not yet organized)	110,806	90,000, scrip.
Georgia State College of Agriculture and the Mechanic Arts, Athens, Ga. (department of University of Georgia)	243,000	.....
North Georgia Agricultural College, Dahlonega, Ga *b*	.....	270,000, scrip.
Illinois Industrial University, Urbana, Ill	319,494	480,000, scrip.
Purdue University, La Fayette, Ind	212,238	390,000, scrip.
Iowa State Agricultural College, Ames, Iowa	500,000	240,000, place.
Kansas State Agricultural College, Manhattan, Kans	290,000	90,000, place.
Agricultural and Mechanical College of Kentucky, Lexington, Ky	165,000	330,000, scrip.
Louisiana State Agricultural and Mechanical College, Baton Rouge, La	(*c*)	210,000, scrip.
Maine State College of Agriculture and the Mechanic Arts, Orono, Me.	116,359	210,000, scrip.
Maryland Agricultural College, College Station, Md	112,500	210,000, scrip.
Massachusetts Agricultural College, Amherst, Mass	157,538	360,000, scrip.
Massachusetts Institute of Technology, Boston, Mass	78,769	
Michigan State Agricultural College, Lansing, Mich	275,104	240,000, place.
University of Minnesota, Minneapolis, Minn	*d*178,000	120,000, place.
Agricultural and mechanical department of Alcorn University, Rodney, Miss	113,400	210,000, scrip.
Agricultural and Mechanical College of the State of Mississippi, Starkville, Miss	115,000	
University of the State of Missouri:		
Agricultural and Mechanical College, Columbia, Mo	5,000	330,000, place.
School of Mines and Metallurgy, Rolla, Mo	.....	
University of Nebraska, Lincoln, Nebr	.....	90,000, place.
University of Nevada, Elko, Nev	90,000	90,000, place.
New Hampshire College of Agriculture and the Mechanic Arts, Hanover, N. H.	80,000	150,000, scrip.
Rutgers Scientific School of Rutgers College, New Brunswick, N. J.	116,000	210,000, scrip.
Cornell University, Ithaca, N. Y	602,792	990,000, scrip.
University of North Carolina, Chapel Hill, N. C	125,000	270,000, scrip.
Ohio State University, Columbus, Ohio	507,913	630,000, scrip.
State Agricultural College, Corvallis, Oreg	.....	90,000, place.
Pennsylvania State College, State College, Pa	439,186	780,000, scrip.
Brown University, Providence, R. I	50,000	120,000, scrip.
South Carolina Agricultural College and Mechanics' Institute, Orangeburg, S. C	.....	180,000, scrip.
Tennessee Agricultural College, Knoxville, Tenn	271,875	300,000, scrip.
Agricultural and Mechanical College of Texas, College Station, Tex.	209,000	180,000, scrip.
University of Vermont and State Agricultural College, Burlington, Vt.	122,626	150,000, scrip.
Virginia Agricultural and Mechanical College, Blacksburg, Va	190,000	300,000, scrip.
Hampton Normal and Agricultural Institute, Hampton, Va	95,000	
West Virginia University, Morgantown, W. Va	90,000	150,000, scrip.
University of Wisconsin, Madison, Wis	244,805	240,000, place.

Total of 9,600,000 acres. In place, 1,770,000 acres; scrip, 7,830,000 acres.

a Prospective endowment is the Congressional grant to agricultural colleges, amounting in Colorado to 90,000 acres; not yet in the market.

b Receives annually from the University of Georgia $3,500, part interest of the land scrip fund.

* $327,000 of State bonds, scaled to $196,200 of new State bonds.

d Estimated.

There appears to be no ground for criticism of the financial management of the colleges of agriculture and the mechanic arts or of the other institutions receiving the benefits of the national land grant, since their organization, the selection of trustees and faculties, and the commencement of instruction. The sums originally obtained by the several States from the sale of their land scrip have remained unimpaired, with a few exceptions. In no State are the productive funds of the institution to which the national aid was allotted more than $5,000 less than the total proceeds of the land sales as given in a report made to Congress in 1875. In Kentucky and Maryland the exact sum realized and the amount of productive funds reported are the same. In Rhode Island the sum received is kept intact and separate, and its income used for scholarships.

The universities and colleges which have received the benefit of the grant have a total amount of funds largely in excess of the amount obtained from this source. How far they have kept this fund distinct from others cannot be answered by the data at hand. The amounts received by the institutions established or reorganized solely or primarily in furtherance of the purposes of the Congressional land grant have been largely augmented by individual donations and State appropriations. The original grant formed but a nucleus, around which funds for building purposes, for the purchase of libraries and educational appliances, for buying and stocking farms, have gathered. Sometimes the gifts have been princely; oftener they have been in accordance with the moderate fortunes of those for whose benefit the institutions were created. That such men have given is gratifying evidence of their favorable opinion of these institutions. But their gifts, though so acceptable, have not been sufficient to provide the expensive outfit which any school of applied sciences must have. As the president of the trustees of the Maine State College of Agriculture and the Mechanic Arts recently said:

> How to establish and maintain colleges to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, and accomplish this in a manner to meet the exacting requirements of the times without the expenditure of a considerable amount of money, is a problem no board of trustees has ever been able to solve.

The expense of teaching theoretically the industries and the related sciences is no greater than that of teaching mathematics or languages. The average ratio between the expense of instruction in ten colleges and universities and their entire expenses in 1877–'78 was 67.2. It is the greater capital which must be unproductively invested that makes technical schools expensive. Shops, farms, laboratories, and museums are not furnished without large outlay. The shop of the Worcester Free Institute, three stories in height and covering an area of 6,600 square feet, is equipped with machinery and tools from cellar to roof. The basement of the building occupied by the Stevens Institute of Technology, having an area of nearly one-fourth of an acre, is well filled by machinery; the first story is largely occupied by laboratories and museums. Such extensive provisions do private technical schools deem necessary to the proper fulfillment of their work as teachers of the mechanic arts.

Public institutions cannot do similar work without similar opportunities and appliances. These have not been given the colleges of agriculture and the mechanic arts. No part of the national aid can be used for obtaining them. Complaints because the institutions receiving an annual stipend of a few thousand dollars do not occupy the same ground

and afford the same facilities for mechanical instruction as munificently endowed polytechnic institutes, whose appliances have cost hundreds of thousands of dollars, and whose instruction is sometimes embraced in a single course, are unreasonable and unjust. Those institutions which have attempted instruction in the mechanic arts are doing good work considering their means and the numerous other branches of instruction to which they are required to give attention. Only one agricultural college has as great an amount of productive funds as the former of the institutions mentioned, and but four have as large an endowment as the latter.

The expensiveness of technical institutions is also shown by the amounts expended by foreign schools. For example, the annual expenditure of the Imperial Technical School of Moscow in 1878 was about $140,000; its receipts, $160,000; its capital, $2,030,000.

Reference has already been made to the ratio between the expense of instruction and the total expense of educational institutions. It is impossible to give this ratio, as it exists in agricultural colleges, with the accuracy which is necessary to give exactness and authority to the figures. The reported sums expended for all purposes and for the single purpose of paying salaries, and the per cent. which the latter is of the former are given by States in the following table:

States in which the several colleges are located.	Total expenses.	Expenses for salaries.	Per cent.
Alabama	$22,500	$17,600	78
Arkansas	17,500	15,500	89
Connecticut	45,118	40,816	90
Illinois	61,876	28,184	46
Indiana	33,213	15,957	48
Iowa	41,000	26,000	63
Kansas	18,000	8,000	44
Kentucky	27,000	16,000	59
Maine	16,815	10,068	60
Maryland	12,000	8,500	71
Massachusetts:			
Agricultural College	22,581	11,137	49
Institute of Technology	60,758	41,655	68
Michigan	29,000	18,000	62
Minnesota	49,000	30,000	61
Missouri:			
University	23,895	18,000	75
Agricultural College	8,600	6,000	70
New York	105,802	74,886	71
North Carolina	17,000	16,000	94
Ohio	48,526	26,461	55
Pennsylvania	30,000	12,457	42
Tennessee	30,884	19,800	64
Texas	19,280	12,000	62
Virginia:			
Agricultural College	21,000	14,000	67
Hampton Institute	32,500	20,000	61
Wisconsin	80,000	40,200	50

The lower percentages are due to expenditures during the year for which the report was made which were outside of the usual current expenses. For example, the Pennsylvania State College, during or near the time for which the above-mentioned outlay was made, devoted $10,000 to the heating of its building, $2,000 to the improvement and extension of its laboratories, and $5,000 to building a professor's house. A considerable share of the $22,581 expended by the Massachusetts Agricultural College was in ways not common to educational institutions, and which produced an income that contributed largely to the reduction of the net expenditure. Its farm account in 1881 exceeded $3,000, and the receipts from farm produce were $1,614; the botanical

account was $2,326, while the income from plant-house and nursery was $2,481. Probably $15,000 of the $80,000 expended by the University of Wisconsin were expended for repairs and permanent improvements to buildings. The expenses of its experimental farm are also large. The Ohio State University paid into the State treasury nearly one-fourth of the money disbursed by it, which sum went to swell the permanent fund held by the State for the university. The Illinois Industrial University, Purdue University in Indiana, and the Kansas State Agricultural College are still growing institutions. They expend for growth as well as for continued existence. This and the industrial departments which they maintain account for the relatively small sums expended by them directly for instruction. Their wide variance from the average of $2 for instruction and $1 for contingent and current expenses is not indefensible; neither is the tendency of some institutions to the other extreme censurable. These are mostly southern colleges, where the present desideratum is the spread of elementary education among the masses rather than the higher and more technical education of professional men.

Faculties.—The faculties of the institutions under consideration are able, and when the income warrants they have a sufficient number of members to give instruction in all the branches which go to make up a practical education. Nothing need be said of those instructors whose work it is to teach languages, mathematics, philosophical sciences, and other branches not directly pertaining to industrial pursuits. Though more numerous, they occupy a field of labor not distinguished from that of ordinary college professors. The peculiar work of the colleges of agriculture and the mechanic arts is done by a comparatively small body of men, and is, in some particulars, unlike anything heretofore undertaken. Forty-three professors are known to this office to be giving instruction in agricultural science. Twelve of them are strictly professors of agriculture, and that alone. The remainder unite some other branch with agriculture or occupy chairs named after some allied science. Eight professors give instruction in chemistry and agriculture; four in horticulture and agriculture; six in botany and horticulture; three in botany, with special reference to agriculture; four in agriculture and natural history; four in entomology; and others occupy nominally chairs of horticulture, geology, and zoölogy, but do the work usually assigned to professors of agriculture. The practice of employing lecturers on topics of interest to farmers has not been generally pursued, though several institutions have done this. The New Hampshire College of Agriculture and the Mechanic Arts employs as lecturers men prominent in that State or in Vermont as successful farmers or as students of agriculture in some of its special departments. Each winter they deliver lectures in a continuous course, open to farmers as well as students. Much practical instruction is given by the several farm superintendents. Ability to impart information ought to be, and usually is, one of the qualifications sought in those who have charge of the work in the gardens and nurseries and on the farms. In some institutions the persons occupying these places are ranked as members of the faculty. In the State Agricultural College of Michigan six members of the faculty are in charge of departments of labor. They are the foreman and assistant foreman of the farm, the superintendent of the horticultural department, the foreman of the gardens, the vegetable gardener, and the florist.

Six colleges of agriculture have professors of veterinary science or special lecturers upon the subject.

The mechanic arts are not being taught in the majority of the institutions endowed with the national land grant. Fourteen professors give instruction in mechanical engineering, applied mechanics, industrial art, or industrial mechanics. Several of these are in charge of shops. In other schools the shops are in charge of separate individuals, so that the number of persons giving instruction in shop work is nearly or quite twice the number of professors in the departments of mechanics. In a single institution, the State Agricultural College of Kansas, there are four superintendents of industrial departments ranking as members of the faculty, which leads to the inference that they give instruction as well as oversee labor. Six professors of metallurgy and mining or chemistry, and about the same number in architecture, are to be counted as doing work as valuable and as industrial in character as that of the instructors in shop work or mechanical engineering.

It was not an easy task for the colleges of agriculture and mechanic arts to obtain instructors in the particular subjects engaging their attention. Especially was this the case when an efficient professor of agriculture was demanded. A theorist would not meet the expectations of those who sought practical results from professional training. An intelligent and successful farmer could not always adapt himself to the changed position which he would occupy as a professor of his favorite occupation. Foreigners might have had the kind of education which would fit a person for the position; but they labored under the disadvantage of having to deal with soils, climates, and systems of labor different from those of their own countries. Nothwithstanding these difficulties, there are instances of persons of foreign birth and education filling chairs of agriculture and kindred sciences with great ability and doing work acceptable to all interested parties. Yet the general rule was well stated by President Abbott, of the Michigan Agricultural College, in his remark that—

> Professors of agriculture, agricultural chemistry, and horticulture had to be made, or, rather, in the face of adverse criticism, with every failure through inexperience open to the world, to make themselves.

The hindrances to obtaining suitable professors of agriculture are now removed. The disciples of the pioneers in agricultural instruction long since began to take up the work of their predecessors, and the graduates of the leading schools of agriculture have received a training which is sufficient to make them capable of giving instruction in all the work of the farm and conducting its practical operations. Many have gone out to fill these places in the agricultural schools of our own country, and some have carried the benefit of their training to other nations. Two of the professors in the Japanese Agricultural College are graduates of the Massachusetts Agricultural College.

Students.—Many remarks are made about the number of students pursuing the technical studies pertaining to agriculture and the mechanic arts that are based upon partial and sometimes untrustworthy information. It is impossible for the best informed to make complete and satisfactory statements on this delicate yet important matter. The returns to this office, though made out as fully and correctly as statistical returns can be, do not point out all the particulars as to the classification of students in agricultural colleges, nor do their reports and catalogues show how many are pursuing studies directly preparatory to industrial pursuits. Some facts are shown. Nine institutions, having each a single course of study, were attended in 1880 by nearly 1,500 students. As there is more or less of agricultural instruction incorporated in their several courses, those in attendance upon these

nine schools are in some measure students of agriculture, and in every sense they are preparing for industrial work. Twelve colleges give the number of students pursuing the special agricultural courses which they offer as 145. Eight institutions, having distinct courses in mechanical engineering or some other department of applied mechanics, are known to have 146 students pursuing these courses. Seven institutions report 92 students in chemistry; two have 91 students in mining and metallurgy; three have 27 students of architecture; one has a course in industrial art attended by 25 students; two report 9 students of mining engineering; and one has 6 taking a specific metallurgical course. The total number of students reported as in attendance in 1880, upon schools endowed by the national land grant was 6,039.

Tuition and scholarships.—The tuition fees of the agricultural colleges are in most cases nominal. They are given in the statistics found in Appendix B, and few comments are necessary. There are a few colleges only in which there are fees, other than those for incidentals, which are not covered by scholarships. Exceptions are found in the institutions located in Connecticut, Massachusetts, and Vermont. All the students in Cornell University pursuing prescribed courses in agriculture and intending to complete the same are granted free tuition; and provision is made for the admission of one student from each of the assembly districts of the State. The appointee is selected by means of a competitive examination. Thus 128 of the most scholarly youth of the State may enjoy the privileges of the university free of charge.

The mode of assigning scholarships and the help they furnish are worthy of further illustration, although the usual practice is simply to remit tuition to those desiring to be relieved of that expense. In North Carolina the commissioners of each county may select annually a native of the State, resident in the county, possessing ability and good character, and being in indigent circumstances; and he "shall be admitted to any classes in the university for which he may be prepared, free of all charges for tuition and room rent." The first section of the act authorizing the appointment of students to Purdue University, Indiana, and defining their privileges therein, is as follows:

> The board of commissioners of each county in this State may appoint, in such manner as they choose, two students or scholars to Purdue University, who shall be entitled to enter, remain, and receive instruction in the same, upon the same conditions, qualifications, and regulations prescribed for other applicants for admission to or scholars in said university: *Provided, however,* That every student admitted to said university by appointment by virtue of this act shall in nowise be chargeable for room, light, heat, water, janitor, or matriculation fees, and said student shall be entitled in the order of admittance to any room in the university then vacant and designed for the habitation or occupancy of a student; and such student so admitted shall have prior right to any such room, subject to the rules of the university, over any student not appointed and admitted as aforesaid.

In Kentucky each legislative representative district is allowed to send, on competitive examination, one properly prepared student each year, between the ages of twelve and twenty-five, to the State Agricultural and Mechanical College, free of tuition charge. The examination is held by a board appointed by the court of claims. Applicants are either those who come of their own choice or those selected by the trustees and teachers of the several common school districts, each district being entitled to send one. Preference is given in examination to energetic, moral, indigent young men. The words "properly prepared student" mean one who can pass a satisfactory examination in reading, writing, spelling, arithmetic as far as decimal fractions, geography, and English grammar.

A recent enactment of the legislature of Texas provided for the maintenance and instruction at the Agricultural and Mechanical College of three students from each senatorial district. The districts are thirty-one in number. One of the students was to be appointed by the senator and the other two by the representatives holding office within the district. One-half of the beneficiaries are to be compelled to take an agricultural course, and the other half a mechanical course of study. They are entitled to board, fuel, lights, washing, and tuition free of charge. The directors of the college, for the purpose of carrying the statute into effect, resolved to request the members of the legislature to determine their appointments by the results of a competitive examination, to require the applicants to be over sixteen years of age, and to assign the appointment of two students in agriculture and one in mechanics to the districts bearing odd numbers, and the appointment of two students in mechanics and one in agriculture to the districts bearing even numbers. In this institution the students reside in the college building and are charged for all their necessary living expenses and tuition at the rate of $130 a year. A similar arrangement is in force in the Maryland Agricultural College, the charges being $142.50 a year; and in the Hampton (Va.) Institute, the charges there ($70 for board and tuition) being met by scholarships. The prevalent custom among agricultural colleges is to furnish rooms at nominal cost, and in one of their buildings to furnish board at actual or estimated cost. Other ways of helping students to make satisfactory arrangements for board are practiced by various colleges. A dormitory accommodating seventy students is turned over rent free by the Ohio State University for the use of a university club. Board, furnished room, fuel, lights, and washing are supplied for less than $3 a week. A system of licensing boarding-houses has been adopted by the South Carolina College. Each house desiring a license must engage through a responsible proprietor, first, that a lady shall always preside at the table; second, that the meals shall be punctually furnished at prescribed hours; third, that intoxicating liquors shall not be furnished or permitted to be used in the house; and fourth, that misconduct will be reported and the house be kept subject to visitation by the faculty. In the Virginia Agricultural and Mechanical College there are two clubs occupying quarters in college buildings, called the farmers' mess and the mechanics' mess. The cost of board is in each reduced to a minimum of five or six dollars a month, room rent being free.

The students of agricultural colleges are encouraged in economy, not merely because their present circumstances require it, but because it will be necessary for them to practice it throughout their lives if they follow industrial pursuits and wish to secure a competence from the results of their labor. As President White, of Purdue University, said to the last graduating class:

> Extravagance in an industrial college is subversive of its chief purpose. Success on the farm or in the shop requires simple habits and wise economy in living, and the young farmer who has not learned this lesson has not completed his preparatory training. A thorough education unfits no one for industrial pursuits, but the acquiring of extravagant tastes and habits may render such an education of little practical value. The spending of money needlessly during four years of college life is certainly a poor preparation for the life of self-denial and thoughtful saving which awaits nine-tenths of our industrial students.

The aid rendered students in agricultural colleges by furnishing them rooms free of charge, and by helping them to accommodations of many kinds, is one reason why these institutions do not seem to be economically managed. Private institutions do little for their students beyond

supplying instruction. Their rooms are rented at paying prices, and advantages gratuitously offered in the case of agricultural colleges are made a source of unreported revenues. The income of ordinary colleges and universities is much smaller, in comparison with the number of students in attendance, than that of the institutions endowed by the land grant. In three States, Maine, Massachusetts, and New Jersey, this rule fails. The average income per student of the colleges of Maine is only slightly in excess of that of the agricultural college. The average Massachusetts college has an income of nearly $300 per student, while its colleges of agriculture and the mechanic arts have only a little more than $170. In New Jersey the comparative incomes of the schools aided by the land grant and of other colleges do not materially differ. From seventeen other States sufficient data have been received to enable a comparison to be made between the amount of income per student received by both classes of institutions. In ten States the income per student of the endowed institution is more than double that of ordinary unaided colleges. There are two additional reasons for this apparent lack of economical administration besides the generous aid rendered to their students already mentioned. These are the character of the work done and the disinclination of private institutions to report their revenues. Single illustrations of both these reasons will suffice. In Massachusetts the income of scientific and industrial institutions of collegiate rank and not endowed by the land grant was nearly $450 per student in 1880, while the corresponding income of the colleges and universities is, as has been stated, in the vicinity of $300. The relative income per student in these classes of institutions in New Jersey is as $300 to $160. This goes to show that scientific and technical training under private administration is more expensive than classical instruction. In illustration of the second reason, namely, that private institutions are not willing to report their income, any State may be chosen. Taking Illinois as an example, it appears that the full incomes of only 18 of the 28 colleges in the State were reported to this office for 1879, while in only one case was the number of students withheld. If private institutions reported their financial condition as faithfully as they do the number of their students the ratio between students and incomes would be much nearer that existing in agricultural colleges than a casual observation of the figures upon which such ratios are usually based would indicate.

Graduates.—None of the colleges of agriculture and mechanic arts have a very large number of alumni. They have not been in existence twenty years, and many of them are of more recent origin. Consequently their graduates are still young, and many of them have not entered upon their permanent occupations. Large numbers have devoted themselves to teaching. In the South the call for teachers is urgent, and it is to the credit of the universities and colleges aided by the national land grant that they have sent out so many thoroughly equipped teachers. In the North and West the occupations chosen by graduates are various and largely industrial. Of 1,000 graduates of institutions located in Northern States, 168 are following agricultural or horticultural pursuits; 141 are teaching; 128 are engaged in civil engineering and similar work; 92 have gone into active mercantile life, and 85 are manufacturers. From these figures it is inferable that at least 60 per cent. of the living graduates of agricultural colleges are engaged in those pursuits which the aid given to their alma maters was intended to promote. The heads of institutions are inclined to estimate the proportion of graduates in industrial colleges even higher. The president of the Kansas State Agricultural College writes, "Of graduates, a few

are teachers, and the rest farmers, business men, or mechanics." The graduates of the Maryland college are said to be devoting themselves to teaching and agricultural pursuits. The president of the board of trustees of the College of Agriculture and the Mechanic Arts in Maine, an institution eminently practical in its purposes and methods, makes the following interesting and significant statement:

> Besides these (156 graduates) nearly 200 young men have had the benefit of its instruction from one term to three and one-half years, making an aggregate of 356 who have enjoyed its advantages more or less fully. As nearly as can now be ascertained, less than 12 per cent. of this number have entered, or are preparing to enter, the liberal professions. On the other hand, 88 per cent. have entered, or propose to enter, other employments. But few of them remain long unemployed after leaving the college. Many are at once sought for responsible positions—some of them before they have finished their course of study. They may be found on farms and in work-shops. Their services are sought as civil and mechanical engineers, surveyors, draughtsmen, foremen of shops, superintendents of mills, agents of business houses, instructors in technical departments of industrial institutions of other States, and in public schools.

The last report on graduates of the Hampton Normal and Agricultural Institute gives interesting statistics. There are 397 living graduates and *senior* under-graduates, a term which seems to be applied to those who left the institute during their senior year. Of this number 363 had been heard from directly. Nearly all had taught more or less, more than half of them in Virginia. One hundred and fifty-three own land or other property; 13 are pursuing studies at other institutions; 10 are in mercantile work; about the same number are clerks and book-keepers; 5 are carpenters; and a large number are scattered among a great diversity of employments. Of those owning land, 7 have above 100 acres; 18, from 50 to 100 acres; 4, from 20 to 50 acres; 14, from 5 to 20 acres; and 59, less than 5 acres. The value of property reported by 2 is $3,000 each; by 10, $1,000; by 17, from $500 to $1,000; by 16, from $200 to $500; and by 6, less than $200.

Courses of study.—The institutions which have received aid from the land grant of 1862 have either single prescribed courses of study or several courses from which a selection may be made. Those in Colorado, Kansas, Massachusetts (agricultural college), Michigan, Mississippi, New Hampshire, South Carolina, and Virginia belong to the former class. One of the schools in Virginia, the Hampton Normal and Agricultural Institute, has a course which embraces few studies not usually pursued in public schools of intermediate grades. Of the remaining eight institutions, six have four-years' courses and two three-years' courses. The studies pursued during the first year by one-half or more of these eight institutions are, algebra in 8 institutions; history, 7; geometry, 6; botany, 6; English studies, drawing, agriculture, 5 each; rhetoric, 4; arithmetic, physics, physiology, and book-keeping come next in order.

During the second year the studies are more varied. Chemistry is prescribed by six institutions. Geometry, trigonometry, surveying, botany, and English studies are each pursued in five institutions; drawing and mechanics in four; algebra and agriculture in three; physics, mineralogy, zoölogy, literature, horticulture, entomology, and modern languages in two institutions.

In the third year chemistry is a part of the course of all the colleges. Agriculture (including horticulture) and mechanics are each prescribed by six institutions; English studies, by five; geometry, surveying, physics, geology, entomology, and physiology, by three.

Mental science and agriculture are studies common to the senior year of the six institutions, having single prescribed courses of four years in

length. Logic is pursued in four; constitutional law, political economy, history, botany, geology, astronomy, veterinary science, and engineering in three each.

This statement shows the general scope of the instruction afforded by agricultural colleges of the kind under discussion. It reveals the fact that agriculture, mathematics, the natural sciences, and English branches have overshadowing prominence as departments of study, and that languages and practical mechanics (a far different thing from theoretical mechanics) are not receiving great attention. The course of study in the State Agricultural College of Colorado, which is outlined in Appendix A, is worthy of notice.

The direct industrial instruction afforded is most often in the line of agriculture and horticulture. The studies pursued in these subjects are not always given. Four of the colleges under consideration do not give an extended course in agriculture. Its principal subjects are presented by lectures, and agricultural chemistry is given a fair share of attention. In the State Agricultural Colleges of Kansas, Massachusetts, Michigan, and Mississippi agriculture is made a prominent and characteristic feature of the course. In Kansas its study is confined to the second and fourth years. In the second year stock-breeding, the cultivation of crops, implements and their use, drainage, and the history of agriculture are considered; in the fourth year stock feeding, rotation of crops, fertilizers, experimentation, and diseases of animals are among the subjects treated. Lectures are given on horticulture, forestry, pomology, and vegetable gardening. In the Agricultural and Mechanical College of Mississippi agricultural instruction is continued throughout the four years. All the leading subjects are presented at considerable length and with commendable thoroughness. In the State Agricultural College of Michigan agricultural chemistry, practical agriculture, horticulture, and landscape gardening are classed as separate departments of instruction, and all that is needed for proficiency in these branches of industry is taught. The formation and composition of soils; the nature and source of food of plants; chemical changes attending vegetable growth; the improvement of soils by chemical means and by the usual fertilizers; the chemistry of the dairy—these and similar topics form the course of work in agricultural chemistry. The subjects of study in practical agriculture, many of which have just been mentioned in connection with another institution, are brought before the students theoretically and practically. Horticulture receives special attention. All the work, from the location of the garden to the choice of a time and place of marketing its products, is carefully taught. The selection of sites for orchards, the kind of trees to set out, pruning, the destruction of injurious insects, and the care of fruit are studied in the department of pomology. In the Massachusetts Agricultural College the instruction in agriculture and horticulture includes every branch of farming and gardening practiced in the State, and is both theoretical and practical. Each topic is discussed thoroughly in the lecture-room, and again in the plant-house or field, where every student is obliged to labor six hours a week, and may do additional work for wages if it does not interfere with his study.

Prominence has been given to the subjects pursued in institutions where no selection of courses and little or no opportunity for election of studies were allowed, because all the students in them take up the work prescribed, and become more or less familiar with the agricultural subjects presented. The number of these institutions is not as great as of those which offer an agricultural course as one of several open to

the student. Few students in colleges of the latter class choose the agricultural course. Probably seventy per cent. of those who pursue systematically the study of agriculture in their collegiate course are found in the nine institutions of the former class. Yet there are at least twenty schools which have agricultural courses and one which provides a course in horticulture. The courses in agriculture are of a grade similar to that of regular college courses. They substitute agriculture for studies which may be omitted from a course without impairing its industrial value, or which are technical or professional in character. The remaining studies furnish a good general education, a foundation for a wide range of investigation in the departments of agriculture, and a facility in imparting and applying special knowledge. History, literature, mathematics, modern languages, and natural sciences form the ground-work of every course. The importance of these studies, their place in a liberal education, and the advantages which familiarity with them gives to persons of every calling are known to all intelligent men. All agricultural courses have a line of general studies such as has been indicated.

In the Royal Agricultural and Forestry Academy at Hohenheim, in Wiirttemberg, [says Professor Runkle] the general studies include the elementary mathematics, with trigonometry and descriptive geometry, physics, and chemistry, and the natural sciences which apply in farming, fruit, and forest culture, and the raising and training of domestic animals. The practical studies include the history and literature of farming, farm productions in general, with special instruction relating to the culture of hops, grapes, fruits, and vegetables, the breeding, rearing, diseases and uses of domestic animals, the production of wool and silk, and bee culture, farm management, with practice in the drawing of plans and specifications for such management, and farm book-keeping. Farming technology is taught through practice.

The studies which are considered by Mr. J. Scott Russell as necessary to an agricultural education are the following:

Farming knowledge.	Technical teaching.
Nature of soil	Surface geology.
Structure of plants	Anatomical botany.
Food of plants	Physiological botany.
Manures	Agricultural chemistry.
Structure and constitution of animals	Comparative anatomy.
Rearing of animals	Animal physiology.
Diseases of animals	Veterinary medicine and surgery.
Laying out of farms	Land surveying.
Draining and irrigating	Surveying and levelling.
Gates and fences	Practical mechanics.
Construction of farm buildings	Agricultural economics and plan drawing.
Improvement of seeds and breeds	Agricultural geography.
Ploughs, wagons, implements	Theoretical mechanics.
Steam engines and machinery	Elements of mechanism.
Fruit trees and timber	Technical botany.

The course of study for graduation in agriculture in the Virginia Agricultural and Mechanical College requires four years of English studies and of mathematics; three years of agriculture and horticulture and of history; two years of chemistry and of French or German; and one year or less of natural philosophy, book-keeping, drawing, geology, and mineralogy, botany, zoölogy, and moral philosophy.

The peculiar studies of an actual agricultural course are not matters of common knowledge with the people, either as to the extent to which they are pursued or the preparation they give for farm work, and information on these points is difficult to obtain. A few facts have been brought out with regard to the extent to which agriculture is taught in the United States by special courses.

Twenty-one institutions endowed with the national land grant offer twenty-three courses in agriculture. Seventeen of the twenty-three are four years in length, four are three years, one is five years, and one two years. Of the seventeen having courses four years in length, seven introduce agricultural studies into every year of the course, four require one year of general study before special branches are taken, five two years, and one three years. Of the four courses which are three years in length, one only has any part exclusively devoted to general study. The agricultural instruction given in those institutions in which it is continuous during four years includes nearly every subject taught in connection with agriculture. Shorter courses either omit some branches or abridge instruction in them. None of them bears any marked similarity to any other. No relation seems to have been discovered between one branch of agricultural study and another by which some classification of them for the purposes of consecutive study can be made. The studies found in senior year in one college are almost as often in the freshman year of others. The topics pursued during freshman year by the greatest number of institutions are general agriculture, entomology, horticulture, and agricultural botany; in sophomore year horticulture, landscape gardening, agricultural chemistry, agricultural botany, and animal anatomy and physiology; in junior year farm economy and management, veterinary science, rural law, farm machinery, crops, and farm engineering; in senior year, rural economy, rural architecture, history of agriculture, botany, horticulture, and chemistry.

Manual labor is required of the students in several agricultural colleges. In the State Agricultural College of Colorado they are required to spend at least two hours of each day in labor on the farm or in the shop, under the direction of their instructors. A labor system is connected with the course in agriculture of Purdue University, Indiana, by which each student is to labor two hours daily in the experimental field, green-house, or campus, during the fall and spring terms, while in the winter term an abbreviated course in the mechanic shop is provided, consisting of wood-work and iron-work, in which forge-work is made a leading feature.

One hour of daily practice is required in the industrial departments of the Kansas State Agricultural College. Students are encouraged to work more, and most of the labor needed on the farm and in the garden, shops, and offices is performed by students. Nearly all of it is under the direction of superintendents, and is instructive. The provisions with regard to manual labor in the Maine State College of Agriculture and the Mechanic Arts are as follows:

> The maximum time of required labor is three hours a day for five days in the week. In the lowest class the students are required to work on the farm, and they receive compensation for their labor according to their industry, faithfulness, and efficiency, the educational character of the labor being also taken into account. The maximum price paid is ten cents an hour. The labor is designed to be, as much as possible, educational, so that every student may become familiar with all the forms of labor upon the farm and in the garden. The students of the three upper classes carry on their principal labor in the laboratory, the drawing-rooms, the work-shops, or in the field, and for it they receive no pecuniary consideration, since this labor is of a purely educational character.

In the Massachusetts Agricultural College six hours a week of work in the plant-house or field are required. In the Michigan State Agricultural College all the students labor three hours daily, except when exempt on account of physical disability. (See appendix A.) The same rule exists in the Agricultural and Mechanical College of Mississippi. The labor is arranged as far as practicable to illustrate studies and lect-

ures. The junior class generally is assigned work in the gardens and orchards and on the grounds, the sophomore class on the farm, the freshman and senior classes on the farm or in the garden, or wherever their studies may find best illustration. The Agricultural Colleges of South Carolina and Virginia require manual labor. The trustees of the Iowa Agricultural College have made the following rules regulating manual labor :

(1) The manual labor required by law of students in the college is divided into two kinds, viz: uninstructive labor, which shall be compensated by the payment of wages; and instructive labor, which shall be compensated by the instruction given and the skill acquired.

(2) Uninstructive labor shall comprise all the operations in the work-shop, garden, upon the farm, and elsewhere in which the work done accrues to the benefit of the college and not to the benefit of the student. Instructive labor shall embrace all those operations in the work-shop, museum, laboratories, experimental kitchen, upon the farm and garden, in which the sole purpose of the student is the acquisition of skill and practice.

(3) Students shall engage in instructive labor in the presence and under the instruction of the professor in charge. * * *

(4) The labor furnished by the school of agriculture, of veterinary science, and of engineering is given by each exclusively to its own special students.

Manual labor has a large place in the system of instruction of the Hampton (Va.) Normal and Agricultural Institute. For the sake of discipline, as well as instruction, all its students are required to labor. Day scholars work an hour a day, without compensation, at such industries as may be assigned them. Boarding students usually work one school day each week and the whole or half of Saturdays. Suitable young persons who are eager for an education, but have not the means for procuring it, are furnished work and taught in the evening, so that they can be gaining some knowledge while accumulating the money necessary for pursuing a more complete course of study. The student earnings for the year ending June 30, 1881, were almost $25,000.

There are physical, mental, and moral results which are expected to come from manual labor. President T. C. Abbott, of the Michigan Agricultural College, enumerates the following : First, physical strength and endurance, which are necessary to the farmer, are promoted by it; second, a wide range of practice in farming, horticultural, and other practical operations is given; third, a working familiarity with the sciences whose principles are involved in the processes of agriculture is acquired; fourth, the opinion and the sentiment that farm labor is not degrading, and that labor and culture are not mutually incompatible, are inculcated. The benefits of manual labor in the State Agricultural College of Colorado are held to be financial aid, instruction in methods of work, health derived from regular exercise, and a correct idea of the importance of labor. Evidence of the propriety of giving manual labor a recognized place in agricultural colleges is furnished in that the institutions which have given it a permanent and prominent place have been eminently successful. Recently established agricultural colleges have adopted after due consideration the manual labor system, and persons who have had experience with the operation of the system and observation of its results are ready to testify in its favor.

A large part of the manual labor of students has been utilized in the work of agricultural experiment, and their laboratory practice has turned toward the solution of chemical problems of importance to the farmer. In either case the improvement of the student and the information of the public were objects to be attained. Agricultural colleges have commonly done more in the line of field experiments, under the direction of skillful superintendents, than in the determination of ques-

tions immediately answered by chemistry, except in the analysis of fertilizers. Where agricultural experiment stations have been maintained at State expense they have chosen the laboratory as their principal workshop. When the Connecticut agricultural experiment station was established in 1877 it was given not a farm, but a laboratory. Its first and prominent work was the analysis of fertilizers. The testing of seeds, the analysis of feeding-stuffs, the relation of soils to water, and the improvements of methods of agricultural analysis were soon made subjects of experiment. The work required of the North Carolina experiment station was the analysis of fertilizers, minerals, mineral waters, well waters, articles of food and drugs, and the examination of cases of supposed poisoning. The station has also analyzed marls and chemicals used in composting, identified plants and insects to ascertain their useful or injurious character, and tested the germinating power of seeds. The results of such work done originally for individuals and of investigations of general interest have been given to the public, and thereby the station has become an educational agency.

The New Jersey agricultural experiment station is located in connection with the Rutgers Scientific School at New Brunswick. It is actively engaged in benefiting practical and scientific agriculture and encouraging land improvement in the analysis of soils and fertilizers, in the trial of experiments, and the publication of bulletins and reports.

The field experiments conducted under the supervision of agricultural colleges are directed principally toward the determination of questions relating to grains, roots, and forage plants. The varieties which are the most hardy and productive are ascertained. Various methods of culture, including the preparation of the soil and the time and manner of sowing and harvesting, are tried. The effect of different fertilizers and different soils is determined. Experiments are extended from the feeding of plants to the feeding of animals, and the comparative effects of early and late cut hay, of grass and other forage plants, of roots and grain, and of different grains are noted. The manufacturing processes of agriculture, dairying, sugar-making, &c., are experimented upon in several States. Irrigation and forestry receive a large share of attention in parts of the West. In fact there are few subjects affecting the farmer which have not been investigated and experimented upon in our colleges of agriculture. The work has been done at points scattered over the country and representing every variation in soil, temperature, moisture, and elevation; it consequently renders service to all kinds and sections of country. It has been done systematically and exactly. The methods of experimenting have been a miniature of the way in which agricultural knowledge is obtained. But instead of rough guesses there have been exact measurements. Instead of memory of circumstances there has been a record kept. Instead of hasty and prejudiced conclusions there have usually been deliberate judgment and impartial opinions. In this way many economical truths are quickly and correctly ascertained by which the farmer who intelligently applies them is saved from disastrous experiment and directly educated in his occupation.

The courses of study in the mechanic arts are not characterized by irregularity and diversity, but possess unity of plan and systematic arrangement. They embrace the courses in mechanical engineering, chemistry, mining, and metallurgy, and a few individual courses in industrial art, architecture, and kindred branches. Fourteen endowed institutions teach mechanical engineering or its equivalent. Two of them have no shops or mechanical appliances, and incorporate instruction in mechanics with a civil engineering course modified for the in-

struction of those wishing to engage in mechanical engineering. Four of them confine the professional studies to two years; five have courses in which technical studies are pursued for three years, and three have courses four years in length, with special studies and practice throughout. The scope of instruction in this branch of mechanic arts is indicated by the courses which are given at length in Appendix A. The practical work presents points of interest which may be properly noticed at some length. Ten institutions, at least, have shops and unite theory and practice in training for mechanical pursuits. Two others have more or less mechanical apparatus. The shop practice of the ten institutions which are known to give prominence to practical work may be considered in an order corresponding with the alphabetical arrangement of the States in which the several institutions are located.

A department of mechanics and drawing was opened in September last in the State Agricultural College of Colorado. A building has been erected and shops for bench-work in wood and iron and for forging have been equipped. The full furnishing of the department will be pushed forward rapidly, so that students may complete a course in mechanics similar to that provided in eastern schools.

In the Illinois Industrial University the student of mechanical engineering receives practice in five shops which are devoted to (1) pattern-making, (2) blacksmithing,(3) molding and founding, (4) bench-work for iron, and (5) machine tool-work for iron, respectively. In the first the practice consists of planing, turning, chiselling, and the preparation of patterns for casting. The shop has a complete set of tools, benches, and vises. The common operations of blacksmithing are undertaken in the second shop, and those of casting in the third. In the fourth shop there is first a course of free-hand bench-work, and afterward the fitting of parts is undertaken. In the fifth shop all the fundamental operations on iron by machinery are practiced. The actual work done is carefully outlined beforehand by drawings; and the designing of machines and their elements is required.

The school of mechanics of Purdue University offers the kinds of practice mentioned above. The course is taken in the freshman and sophomore years. Relatively more time is devoted to simple carpentry. The shop contains five benches for wood-working, with as many complete sets of tools, and machines for iron-work, such as lathes, planers, drill-presses, and emery-grinders. All the tools requisite for the work to be performed are supplied.

In the Iowa Agricultural College shop practice is required during freshman, junior, and senior years. The work of freshman year is of a general character, and occupies only two hours a week. No regular course is prescribed for the other years. An original design of a machine must be made, but it is not stated that the machine must be constructed.

In the Maine State College of Agriculture and the Mechanic Arts there are two shops equipped according to the Russian system, and work in them is required of all who take the course in mechanical engineering. In the second term of sophomore year a course in forge-work is given, by which familiarity with the methods in use in actual construction is gained. A similar course in vise-work is given in junior year. The facilities for practice are being increased as funds for the purpose are obtained.

In the Massachusetts Institute of Technology there is a course of two years in mechanic arts designed for those who have received a grammar-school education and wish to enter as soon as possible on industrial

pursuits. The shop-work of the first year embraces carpentry and joinery, wood-turning, pattern-making, and foundry-work; of the second year, iron-forging, vise-work, and machine tool-work; the students in the course of mechanical engineering are required to devote considerable time to these kinds of work. It is intended that they shall learn principles rather than construct machines.

The shop practice in the department of mechanic arts of Cornell University embraces work requiring the use of all hand-tools and of the machines ordinarily employed in machine-shops, and requires two hours daily of the student of mechanic arts. The department occupies a three-story building and basement, 42 by 110 feet, with an engine-house, a brass and iron foundry, and a stereotype foundry in immediate connection. The first floor of the main building is occupied by a machine-shop and printing-office; a part of the basement by a forge-shop. The cost of the building and equipments was about $42,000. Among the equipments are hand and lathe tools of the usual kinds; instruments for mechanical experiments, and a collection of drawings from those of technical schools abroad. The instruction is given by two professors, one assistant, and one foreman. Skilled workmen are also to be employed.

The Ohio State University requires of students in the mechanical course three terms of elementary practice in the use of tools and one term of machine construction. The laboratory has been equipped recently, and this branch of industrial instruction is receiving increased attention.

The Agricultural and Mechanical College of Texas, which has recently been reorganized with reference to practical work in agriculture and mechanic arts, has a shop fitted up as completely as the State appropriation for the purpose would permit. A sufficient variety of tools has been furnished to enable the student to receive practice in carpentry, wood turning and sawing, vise-work, the operating of metal-working machinery, and steam engineering. The prescribed course of shop-work covers two years, and the work of the third year may be conformed to the student's chosen line of investigation.

The University of Wisconsin introduced a course in mechanical engineering in 1877, and a shop was provided and equipped. Practice is continued throughout four years. Machines are constructed and a variety of profitable work done, as well as many processes learned solely for their illustrative and disciplinary value.

Methods of shop-work are either instructive or constructive. The instructive method proceeds on the theory that there are certain elementary operations underlying the important branches of mechanical labor, and that skill in these opens the way for the ready acquisition of the minor details which make up the differences between trades. These elementary operations are classified according to their simplicity and their interdependence. The scientific principles which control their performance and the work itself are taught to classes by lectures and recitations, and the actual work is illustrative of the theoretical instruction. The fundamental idea of the constructive method is that completed work must be done by the student in order that his training shall be practical; therefore he is given work in the construction of machines or other articles of use, and is taught how to perform each branch of the work as it is reached, and is helped over difficulties which are actually in his way.

The instructive method is adopted in the main by the Russians in their system of instruction in mechanic arts. The principles which

underlie this system are concisely stated by Prof. J. D. Runkle, of the Massachusetts Institute of Technology, as follows:

> The ideas involved in the system are, first, to entirely separate the *art* from the *trade*, the *instruction* shops from the *construction* shops; second, to teach each art in its own shop; third, to equip each shop with as many places and sets of tools, and thus accommodate as many pupils as the teacher can instruct at the same time; fourth, to design and graduate the series of sample to be worked out in each shop on educational grounds; and, fifth, to adopt the tests for proficiency and progress.

The elementary operations are performed in their natural order and place, and learned not by themselves as isolated facts, but in their relations to each other and to details.

The number of institutions endowed with the national land grant which have special courses in chemistry is ten. They are mostly located in the East. This branch of instruction is of prime importance to those contemplating manufactures involving the use of compounds, and such industries are more developed in the North and East than in the South and West. Those institutions in the latter sections which have undertaken to give thorough chemical instruction are to be commended. By so doing they are contributing powerfully to the wealth of the State and the prosperity of its people. The work of those institutions which have special courses in chemistry is presented in Appendix F.

Mining and metallurgy are given special prominence in at least seven institutions endowed with the national land grant. The courses of instruction in these branches is outlined in the statements of work done by individual institutions as given in Appendix A. Into these courses, history, literature, political economy, and the branches of law connected with mining are introduced for the sake of the culture and information they afford. French and German have a place, as familiarity with them is necessary in order that the engineer may avail himself directly of the many valuable treatises and reports on engineering published in those languages. Leading branches of natural science, and particularly those which treat of minerals, are taught in all the schools. The courses differ chiefly in the kind and extent of purely technical study.

The course in mining engineering in the Alabama Agricultural and Mechanical College is three years in length, two of which are undergraduate, one graduate. The studies of the undergraduate years are not very different from those of the course in civil engineering. In the first year of professional study (the junior) laboratory work is taken by the students in mining, and the drawing and engineering study done by them differs slightly from that done by the civil-engineer students. The next year the courses differ chiefly in the kind and amount of scientific study and in the substitution of laboratory work for engineering studies. A statement of the course of study for the graduate year has not been received.

The Illinois Industrial University affords training in mining engineering and in metallurgy. The student of mining engineering takes the course in civil engineering, substituting for special studies not closely related to their profession portions of the metallurgical course. This latter does not differ greatly from the chemical course. The assaying and analysis of ores, and the analysis of metallic compositions, mineral waters, and coal are undertaken in place of work less important to the metallurgist. Provision is made in the general laboratory for metallurgical and assaying laboratories, with stamp-mill, furnaces, and other apparatus required for practical instruction.

In the Sheffield Scientific School, New Haven, Conn., those wishing to become mining engineers go through the regular course in either civil

or mechanical engineering, and then devote a year to studies fundamental to the education of a mining expert.

The Ohio State University has a course in mining engineering. The studies of the first three years are nearly in common with the other engineering courses. Considerable time is devoted in the third year to metallurgy. In the last year the studies are distinctly professional, including theory of veins, mining, coal-washing, and the mechanical treatment of ores, metallurgy, assaying, mineralogy, and blow-pipe analysis, strength of materials, and plans, specifications, and estimates for metallurgical works. It is intended that the course shall secure to the student careful instruction in mining and in the preparation and metallurgical treatment of ores.

The University of Wisconsin offers special courses in mining engineering and metallurgy. The student that has pursued the civil engineering course for two years may choose either of them at the commencement of junior year. The studies of the mining engineering course are chiefly higher mathematics, theoretical and applied mechanics, physics, civil engineering, drawing, and geology. Mining engineering proper is taught during the last two terms of the senior year. The metallurgical course is principally composed of chemical work. Metallurgy itself is taught during the fall and winter terms of the senior year. The subjects taken up in order are general principles, fuels, furnaces, and metals. Excursions are made to smelting establishments and descriptions of actual operations required. Assaying is taught during the spring term of junior year to the students in mining engineering and metallurgy. The assay laboratory is provided with tables for eighteen students, six crucible furnaces, two roasting furnaces, two large muffle furnaces for cupellation and scorification, a Blake crusher, bullion rolls, &c. The laboratory work is so extensive that he who completes it is deemed an expert in assaying.

The college of mining of the University of California is intended to give thorough professional training in mining engineering. The full course leading to the degree of mining engineer is six years in length. The first two years are nearly the same as those of other scientific colleges. The instruction of the next two years is more directly connected with mining. The scientific studies are taught as far as possible with direct reference to their connection with mining and metallurgy. The last two years are post-graduate, and the course of study is yet to be perfected. The metallurgical laboratory furnishes the best facilities for assaying and metallurgical practice, and various collections aid the student by illustrating collateral branches of study.

The University of Missouri has a department, called the School of Mines and Metallurgy, located not at the same place as the university, but to the southward from it, at Rolla, in the district in which iron, lead, and zinc abound. Several courses of study, each three years in length, are provided, all of them giving prominence to studies in mining and metallurgy. The course in mining engineering is the standard one of the school. The others are identical with it during the first year and similar to it in many respects during the other two years. The engineering itself is taught principally by lectures and field practice, and the operations of metallurgy are performed in the laboratory.

In the Massachusetts Institute of Technology there are three courses of study which deal with mining. They are styled the courses in mining engineering, in geology and mining, and in metallurgy. The technical studies of each extend over three years. The special instruction in mining consists of a course of eighty lectures, delivered to students

in the third year, on the general character of the various deposits of useful minerals and on the theory and practice of mining operations. In the fourth year, ore-dressing and metallurgy are taken in a course of sixty lectures, accompanied by a series of continuous practical exercises in the concentration and smelting of ores in the mining and metallurgical laboratories.

It has been the aim in outlining the instruction given in agricultural colleges to show what opportunities are afforded by them as a body for the acquirement of training for industrial pursuits. Agriculture, mechanics, chemistry, and mining have been considered in turn, and it has been seen that there are numerous schools in which each subject receives marked attention. To some the results of these national schools of science seem meager and discouraging. They are unwilling to wait for harvest, until there has been time for growth and ripening. The space between sowing and reaping is too wide for their patience. The truth of this is seen in movements that hasten to maturity more rapidly than can a new system of schools and a new line of education. A single score of years measures the life of these schools, a period not long compared with the time in which education has been coming to its present advancement, and none too long for a satisfactory trial of methods and studies. Earlier conclusions did not carry that weight which those reached now will have. Individual minds cannot but be convinced by the facts of this report that great benefits have accrued from the investment of public and private wealth in these schools. Certainly scientific training and investigation have been promoted as in no other way. Improved methods of instruction and enlarged facilities for experiment have been introduced by their influence and example. Theory has been more largely supplemented by practice. Abstract rules are learned by their application to practical affairs. The larger part of the technical training in this country at present is being done by institutions which have been stimulated, if not established, by national aid. They are paying the just debt with ample interest by sending out men and women to develop, utilize, and economize the resources of the country; to maintain the fertility and increase the productiveness of its fields; to construct and control its machinery; to improve its manufactures, augment their variety, and lessen their cost; and to bring its untold mineral wealth into the use of its people.

SECTION 2.

INDUSTRIAL EDUCATION IN SCHOOLS OTHER THAN THOSE ENDOWED WITH THE NATIONAL LAND GRANT.

SCHOOLS OF SCIENCE.

Besides the schools endowed by the national land grant, there are some thirty other schools and collegiate departments furnishing similar instruction. Extended statements concerning a few schools representative of this class are given in Appendix C, viz: The Worcester (Mass.) Free Institute, the Stevens Institute of Technology at Hoboken, N. J., and the Polytechnic and Manual Training Schools of Washington University, Saint Louis, Mo. A statement of the condition of industrial and technical education in the institutions of this class not named above, and other facts concerning these institutions which have a bearing upon the same subject, are briefly given below.

In San Francisco, Cal., there is an institution, conducted by the pri-

vate enterprise of A. van der Naillen, for practical instruction in the departments of engineering, assaying, &c. There are 4 instructors, and usually from thirty to fifty students, many of them women. The several courses are wholly directed toward the immediate attainment of practical knowledge of the studies pursued, the time spent in the school being usually only a few months.

The State School of Mines, recently established at Golden, Colo., aims to adapt itself to the mining and metallurgical interests of that State. It is dependent on the State for its support, and received an appropriation of the proceeds of a State tax of one-fifth of a mill, amounting to $10,000 in 1880. The faculty has 7 members, and the students in attendance, 1880, numbered twenty-six, many of whom were ladies. Tuition is $20 a term, or $60 a year. There are two regular courses of study, one in mining engineering and one in metallurgy, each covering three years, and facilities are offered to those wishing to pursue special courses of similar study. The school possesses a good library of standard scientific works, and is liberally provided with apparatus for regular work and for experimental illustration. A museum is in process of formation with a special department representative of the fossils and minerals of the State.

The Rose Polytechnic Institute has the following history: About twelve years ago Mr. Chauncey Rose, of Terre Haute, Ind., placed over half a million dollars in the hands of ten trustees for the endowment of an educational institution at that place. His only restrictive provision was that the school should be "for the promotion of technical education." He instructed the trustees to obtain the best light they could and then decide upon the character and scope of the school. European and American schools and methods were examined, and the conclusion reached was that the Worcester Free Institute was the best model upon which to construct the institution. A site of ten acres was secured, and a shop and an administration building erected. The next move on the part of the trustees was to obtain a president for the school, who should take charge of the incipient institute. Prof. C. O. Thompson, principal of the Worcester Institute, was decided upon, and, after several attempts, the trustees finally secured him. He will have personal supervision of equipping the shops, arranging a course of study, and purchasing a library, and of the details of organization. The institute has an annual income of $30,000 and reserve accumulations amounting to $75,000 which can be applied to the purchase of appliances.

The Boston University, Boston, Mass., announces that the place of its college of agriculture is supplied by the State Agricultural College at Amherst. A college of commerce and navigation is provided for by statute, and will be established as soon as the necessary funds shall be secured. The School of All Sciences connected with the university furnishes to specialists instruction in all the leading branches of advanced study.

The Massachusetts Normal Art School at Boston contributes largely to industrial education. It was established in 1873 for the purpose of affording opportunities for special instruction to those who intended to teach. There were at that time many who needed this instruction, as drawing had been recently included among the branches required to be taught in the public schools of the State, and free instruction in industrial or mechanical drawing was required to be provided by the larger cities and towns. The great obstacle to the carrying out of the law was the lack of suitable teachers. The training and influence of the normal school, under the management of Walter Smith, has

been directed primarily to supplying this deficiency. Incidentally it has educated artists and designers and assisted in bringing art education into popular favor.

The attendance upon the school has been large and generally increasing. In 1880–'81 it was 294. Of these 179 ladies and 43 gentlemen attended the day classes, 32 ladies and 40 gentlemen the evening classes. The students now enter better prepared than formerly for the work of the school. This is a natural result of a general introduction of drawing into the schools, and it has enabled the normal school to advance the course of study. A few years since an examination in free-hand drawing of ornament from copy and in object-drawing from the solid was required to be passed upon admission. The work of the first year was devoted to elementary drawing. The subjects of study of the other three years were, respectively, form, color, and industrial design, the constructive arts, and sculpture and design in the round. These groups could be taken in the order preferred by the individual student, if he showed fitness for the work required.

The school receives its main support from the State, from which it has received annual appropriations. That for 1880–'81 was $17,000. The school year is from October to May, inclusive.

Harvard University, Cambridge, Mass., has two departments especially contributing to industrial and technical education, viz: The Bussey Institution and the Lawrence Scientific School. The Bussey Institution is at Jamaica Plain, Boston, Mass., and has been in operation for about twelve years. Its object is to promote and diffuse a thorough knowledge of agriculture and horticulture, and it aims to prepare young men for work as practical farmers, gardeners, florists or landscape gardeners. The teaching corps consists of professors of applied zoölogy and of agricultural chemistry, instructors in botany, horticulture, entomology, and farming, and a demonstrator in zoölogy. The course of study covers three years, one of them preparatory, one devoted to the regular course of study in the school, and the last spent in advanced study and practical research in some of the departments of science which receive special attention. The aim of the teachers is to give the student a just idea of the principles upon which the arts of agriculture and horticulture depend; to teach him how to make intelligent use of the scientific literature which relates to these arts, and to enable him to make accurate observations and experiments, and draw correct conclusions therefrom.

The Harvard Book says:

> During the second and third years agricultural chemistry, useful and ornamental gardening, agriculture, and applied zoölogy are taught at Jamaica Plain. Instruction is given by lectures and recitations, and by practical exercises in the laboratory and green-house, and by the inspection of field work. In order to give the student a sound basis for a thorough knowledge of these arts, instruction in physical geography, meteorology, the elements of geology, chemistry, physics, botany, zoölogy, entomology, leveling and road building is given the first year at the Lawrence Scientific School, Cambridge.

The object of this latter school is to give complete courses of instruction in the leading departments of science. It is richly endowed, having productive funds amounting to some $730,000, and an income of about $50,000. Its faculty comprises, besides the president, eleven professors, three assistant professors, four instructors, one tutor, and eight assistants. The attendance of students in 1881–'82 was 30. Ample provision for instructing teachers and special students is made. The teachers' courses of study are one year in length, and may be selected

from the elements of natural history, chemistry, and physics. The instruction is mainly given in the laboratories and museums of the university. Every student is taught to make experiments and study specimens. No examination is required for admission. A very worthy class of students enter both in the teachers' class and as special students. The regular courses of study, each four years in length, are (1) civil and topographical engineering, (2) chemistry, (3) natural history, and (4) mathematics, physics, and astronomy. The facilities for illustration, experiment, and investigation afforded to students in any department of Harvard University are, as is well known, very complete.

The University of Michigan offers courses in civil, mechanical, and mining engineering, each four years in length. The course in civil engineering is laid out so as to embody a close imitation of the requirements of active labor. The courses in mechanical and mining engineering are in part similar to the civil engineering course, but include such a range of special studies as enables the graduate to enter understandingly upon the practice of his profession. The studies pursued in the earlier parts of the course by all students of engineering comprise, in mathematics, algebra, geometry, plane and spherical trigonometry, general geometry, and the elements of differential and integral calculus; in French and German, an amount covering in all about two years of study, the choice depending on the language presented on examination for admission; in English, a course in higher English grammar and composition; in physics and chemistry, the elementary principles; in drawing, practice in geometrical and mechanical drawing and the study of descriptive geometry. The special studies which predominate in the latter part of the courses in engineering are those commonly pursued. Practical work accompanies each course. A peculiar feature of the instruction is a course of lectures on naval architecture, discussing the resistance of ships, the power necessary to secure a given speed, buoyancy, stability, wave motion, steadiness, determination of center of gravity and metacenter, and similar topics. Instruction in analytical and applied chemistry is given by accomplished teachers, and supplemented by practice in the excellent and extensive laboratory of the university. Combinations of particular courses are recommended for those seeking proficiency in mineralogical and metallurgical chemistry, medical chemistry and biology, and sanitary chemistry, as well as in general chemistry. The report of Mortimer E. Cooley, U. S. N., professor of mechanical engineering, made to the regents of the university at the close of his first year of service, shows that the course was established in the autumn of 1881 that a complete school of engineering might exist in the institution. The facilities for giving the instruction belonging to this course were insufficient; the demand for it great. A legislative appropriation of $2,500 was devoted to the purpose; and with this sum and slight aid from the university and private individuals a building was erected and equipped with machine and hand tools, an engine, forge, furnace, and other fixtures. Though the shop is limited in size and in variety of furnishing, it is a starting point for improvements and additions.

The Chandler Scientific Department of Dartmouth College, Hanover, N. H., was organized in 1851, in compliance with the conditions of a bequest of $50,000 for the establishment and support of a permanent department or school of instruction in the college in the practical and useful arts of life, comprised chiefly in the branches of mechanics and civil engineering, the invention and manufacture of machinery, carpentry, masonry, architecture, and drawing, the investigation of the

properties and uses of the materials employed in the arts, the modern languages and English literature, together with book-keeping and such other branches of knowledge as may best qualify young persons for the duties and employments of active life. No other or higher preparatory studies are to be required in order to enter said department or school than are pursued in the common schools of New England. A course of four years has been established to carry out, as far as possible, the intentions of the founder. Instruction is given by four professors, six instructors, a lecturer, and a tutor, and the number of students in attendance, according to the catalogue of 1881–'82, is 48, all men. The income of the school is derived from tuition fees, at the rate of $60 a year, and the interest on its productive funds, which now amount to $100,000. The department is well supplied with approved instruments for surveying and engineering, and its students have free use of the college libraries, cabinets, and general appliances.

The Thayer School of Civil Engineering is an institution, also connected with Dartmouth College, which furnishes an essentially post-graduate course in civil engineering extending over two years. It has a productive fund of $55,000; the faculty consists of a president, a professor, and three instructors. The success of its graduates bears testimony to the thoroughness of its instruction.

The John C. Green School of Science of the College of New Jersey, at Princeton, owes its existence to the munificence of the gentleman whose name it bears, his gifts to it having amounted to some $330,000. It was organized as a department of the college in 1873, and aims to give thorough training in science and art, together with a liberal course in certain academic studies, and opportunities for the special pursuit of prescribed departments of study. These departments are three in number, as follows: (1) a department of general science, in which after the second year there are elective courses providing special instruction in mathematics and mechanics, biology and geology, chemistry and mineralogy, also a select course in physics; (2) a department of civil engineering; (3) a department of architecture. The studies of each of these departments cover four years. The extensive laboratories and collections belonging to the college furnish the student ample means for illustration and practice. There were in 1880 twenty instructors and fifty-six students (all males) connected with the school.

The Cooper Union for the Advancement of Science and Art is an institution unique in character, alike from the sagacious beneficence which marks its projection, organization, and administration and the results which it is steadily achieving. The name of the founder, Peter Cooper, has deservedly become a "household word" wherever a broad philanthropy, a genuine uprightness, and a wise conception of human needs and the wants imposed by civilization are understood and recognized. There is little need of extended remark. Mr. Cooper's benefactions have reached nearly or quite $1,000,000. The Cooper Union is now in its twenty-fourth academical year, having been organized and opened in 1857. At that time property was transferred to it by Mr. Cooper which cost $630,226. Since that date Mr. Cooper has given $150,000 as a special endowment for a free library and reading-room. He has also added a story to the building, and by other donations has increased his gifts to nearly or quite the sum named. Since 1857 the trustees have expended in the educational work alone some $898,000, derived largely from the rent of stores and offices connected with the building. The expenditure reported for 1880 was $50,974.

The means of instruction and schools of the Cooper Union consist

of (1) the free library and reading-room; (2) free lectures during the winter; (3) an evening school of science; (4) an evening school of art; (5) a day school of art for women; (6) a school of art for amateurs; (7) a school of wood-engraving; (8) a school of telegraphy. The last four are designed for women students; all are based on practical principles.

The evening school of science embraces fifteen classes or studies, extending the ordinary (English) common school education in the direction of mathematics, mechanics, engineering, and chemistry. It was attended in 1882 by 936 students. While liberty is given them to pursue any branches taught in the school for which they are fitted, a regular course requiring five years for its completion is arranged. The Cooper medal and diploma are awarded to those who successfully complete the course, which is as follows:

First year: algebra, geometry, natural philosophy, and elementary chemistry. Second year: algebra, geometry, elementary chemistry, and astronomy. Third year: trigonometry, descriptive geometry, analytical geometry, and mechanics. Fourth year: analytical geometry, differential and integral calculus, and mechanical drawing. Fifth year: engineering and analytical chemistry. The night school of art embraces classes in rudimental, mechanical, architectural, form, figure, perspective and ornamental drawing, decorative designing, drawing from cast, and modeling in clay. Lectures to the classes are also given. The number of students in 1882 was 1,227.

The day school of art for women is perhaps the best equipped institution for its purposes to be found in the United States. It occupies large and well-arranged rooms, furnished with casts, models, copies, &c., and the teachers possess the highest qualifications. The school contains departments of drawing, painting, normal teaching, photography, and wood engraving. The earnings of the pupils for the year under review are reported at $28,932. The number of students was 756 in the general studies and 150 in the pottery class. The school of telegraphy had 60 pupils. The Western Union Telegraph Company maintains a teacher in the school of telegraphy. Prang & Co., art lithographers, have given $750 per annum for a teacher to the normal drawing class.

The School of Mines of Columbia College, New York City, was established in 1864 for the purpose of furnishing young men the means of acquiring a thorough knowledge of those branches of science which form the basis of the important industrial pursuits. Its system of instruction included, for some time, five courses of study, viz: (1) civil engineering, (2) mining engineering, (3) metallurgy, (4) geology and palæontology, (5) analytical and applied chemistry. A course in architecture has been added recently. The plan of instruction includes lectures and recitations, practice in the chemical, mineralogical, blowpipe, and metallurgical laboratories, and in operative mining; field surveying, projects, estimates, and drawings for the establishment of mines and for the construction of metallurgical and other works; and reports on mines, industrial establishments, and field geology. Each course is four years in length. A large amount of vacation work is done. Each student is expected to visit mines, metallurgical and chemical establishments, and to hand in on his return a memoir, with collections illustrating it. A class in practical mechanical engineering is formed for the vacation of students entering the third year of that course; one in mining for students entering the fourth year of the course in mining engineering; and in geodesy for those equally advanced in the civil engineering course. The class in mechanical engineering in 1881 visited iron works in the city, studying closely the machinery, processes, and

methods used. It was limited to twenty members. The class in mining visited the copper mines of Lake Superior and the Marquette iron region of Northern Michigan. The professor in charge drew up a plan of study for both the copper and the iron mines. The work outlined for the copper region required three weeks for its completion, and included the study of drifting and sinking with machine drills, stoping of copper rock, handling, breaking, and assorting copper rock, timbering, pumps, surface works, shops, stamping of copper rock, concentration of coarse and fine sands by jigs, and treatment of fine sands and slimes. The outline of work in the iron region was also elaborate.

The number of students in mining engineering in 1881–'82 was 111; in civil engineering, 28; in analytical and applied chemistry, 35; in architecture, 2. The first class, which pursues studies preparatory to the special courses, contained 95 members. The total attendance was 275. The degrees conferred are engineer of mines, civil engineer, and bachelor of philosophy.

The School of Civil Engineering of Union College was founded in 1845, for the purpose of giving such instruction in the theory and practice of civil engineering as will fit students for immediate usefulness in the field and in the office. Its faculty consists of a president, nine professors, and a registrar. Its students in 1880 numbered 26. The course of study is completed in four years, and gives special prominence to mechanical draughting, instrumental field work, and numerical calculation. The collection of appliances for illustration is extensive, and facilities for practical work are ample. Students are admitted to all the departments of the college without extra charge. Among these is the department of general culture and of fine art, in which instruction and practice in decorative landscape and figure drawing are afforded, as well as general instruction respecting sculpture, painting, and architecture.

The Rensselaer Polytechnic Institute, Troy, N. Y., offers a course of study in civil engineering extending over four years, and embracing a great variety of subjects, including mechanical, mining, and other forms of engineering. During each summer vacation it is intended, also, to give qualified persons a six-weeks' course in assaying. The institute has a faculty composed of 10 professors, 2 instructors, and 4 assistants, and reported in 1880 104 students and 739 graduates. The appliances for illustration and practice are very complete, and include an observatory, chemical and metallurgical laboratories, collections of birds, shells, minerals, &c., and approved apparatus in all departments of study. The long and successful career of this institute has given it a wide and honorable reputation, so that students come to it from the most distant nations of the world.

The Ohio Mechanics' Institute of Cincinnati was established in 1829 for the purpose of furnishing educational aids to mechanics, manufacturers, and artisans. For many years it has sustained a reading room, courses of lectures, and evening drawing schools. The branches of drawing pursued are three in number, mechanical, architectural, and artistic. The course in mechanical drawing is designed for machinists, founders, blacksmiths, and the like, and was taken by 117 students in 1881–'82; that in architectural drawing is for builders and those in their service, and attendance the last session was 58. The class in artistic drawing did not attract persons of any particular employments, but enrolled 78 from various stations and occupations. About two years ago there was a department of science and art created. Its work has been the publication of a scientific journal in which to publish its own transactions and such other information as it may seem best to include, the

arrangement of meetings for the discussion of questions in science, and the maintenance of evening classes in geometry and mathematics, and in elementary physics and mechanics. These classes are held on Monday and Thursday evenings, the former from 7 to 8.15 o'clock; the latter from 8.15 to 9.30. Instruction is given by lectures. The total expenses of the institute for 1881–'82 were $8,253.34. An effort is now being made to organize a complete school of technology in connection with the institute.

The Case School of Applied Science, Cleveland, Ohio, was founded by deed of trust executed in 1877 by Mr. Leonard Case. It was incorporated after his death in 1880 and organized in October, 1881. The amount of property secured to the institution from his estate is estimated at $1,250,000. The design of the instruction is to give a thorough technical and professional training in the principles of natural and physical science and their applications to the arts. Four years of study will be required to complete its courses. Two of them will be devoted to general training and two to studies of a technical or professional nature. Five courses of this kind are now arranged, embracing mathematics and astronomy, chemistry, physics, civil engineering and mining engineering. Twelve freshmen and 4 special students were in attendance in May, 1882. The faculty had 6 members.

The Toledo (Ohio) University of Arts and Trades was organized in 1872 for the education of artists and artisans of both sexes. Instruction was suspended in 1877 on account of the unproductiveness of its endowment funds, and has not yet been resumed.

The Pardee Scientific Department of Lafayette College, Easton, Pa., was organized in 1866, in accordance with the provisions regulating the use of a generous gift intended for the promotion of scientific education. The gift was made $200,000 in the next year. In 1873 a magnificent building, costing, with its scientific equipment, nearly $300,000, was transferred by the same liberal giver (Ario Pardee, esq.) to the college trustees. It was replaced by him in 1880, after its destruction by fire. The department offers four courses of scientific study. One is a general course four years in length, with the latter part largely elective. By the choice of chemical studies, those wishing to make a special study of chemistry can become thoroughly acquainted with the subject. Provision is also made for advanced and special students who wish to make special researches. The third course is in civil engineering. The course is not strictly confined to that branch of the science, but introduces studies commonly brought under the head of mechanical engineering. The fourth course is in mining and metallurgy. It differs from the one just mentioned chiefly in the last two years. Then mine surveying, mining machinery, mineralogy, lithology, assaying, and similar studies are associated with the direct subjects of mining and metallurgy. Instruction is always supplemented by practice, and the observation and study of the mining, manufacturing, and engineering enterprises of the vicinity contribute largely to the student's education.

The Franklin Institute at Philadelphia was organized in 1824 for the encouragement of science and the mechanic arts. The methods by which it does this include the publication of a monthly journal, the maintenance of an evening drawing school, and a library, and the provision of lecture courses. The journal is intended to disseminate useful knowledge in all matters relating to the practical application of science, but more especially to engineering and the mechanic arts. Each number contains 80 pages of reading matter, and the amount of advertising done by it is very large, so that the journal is self-sup-

porting. The drawing classes are a leading feature of the educational work of the institute. They are held three evenings a week. The course arranged for them is progressive, and includes instruction in mechanical, architectural, and topographical drawing, both free-hand and instrumental, extending over three years. Pupils, if sufficiently advanced, may select any subject of importance to them and receive in it individual instruction. Special classes in architectural and machine drawing have been started recently. The technicalities of drawing, such as the proper selection and use of instruments and materials, the making of clear and perfect lines in pencil and ink, the use of brush and colors, and the relative arrangement of the different views of an object are given particular attention. The library contains 15,968 volumes and a large number of pamphlets, and is said to be one of the most complete collections of works on science and the arts to be found in America. The lectures are intended to be on subjects connected with the callings of members of the institute. Among those delivered during 1881–'82 were four on geology, two on the rise and progress of manufactures in Philadelphia, four on hygiene, two on the microscope and its revelations, four on engineering, six on mechanics, eight on chemistry, two each on astronomy, "machine design and construction," and "drainage and disease and utilization of sewage," and single lectures on "modern photography and gelatine prints, "silk and its culture," "electrotyping," and "mechanical drawing." The lectures are open to the members, each of whom may bring a friend; and complimentary tickets are issued and distributed by members, which admit to the hall five minutes before the lecture commences. The institute has a membership of nearly 2,000, property valued in 1878 at $125,000, and an annual income of some $15,000. Says the president:

> It is true that we neither feed the hungry, clothe the naked, nor heal the sick; but, on the other hand, our efforts are to dry up the sources of hunger, destitution, and disease, and to avert these evils by the diffusion of such knowledge as strengthens and directs the hands of the bread winner, cheapens the cost of food and habitation, and improves the construction of dwellings.

Another Philadelphia institution which aids industrial education is the Spring Garden Institute, which maintains a library and free reading-room, drawing-schools, and schools in mechanical handiwork, and provides courses of lectures and entertainments. The library contained 8,500 volumes in 1880, and was increasing rapidly in size and value. The books are loaned to members of the institute, and are at the service of the public during a large part of the day and evening. The drawing-schools furnish evening instruction in mechanical, free-hand, and architectural drawing, free to members of the institute. The pupils in mechanical drawing are more numerous than in either of the other kinds, and have been graded to some extent. In the schools of handiwork there are classes in vise and lathe work, pattern-making, and the elements of molding and steam-engineering. The course in vise-work includes chipping to line, filing, scraping, and polishing; that in lathe work includes turning, drilling, planing, and dressing of tools at the forge. These two courses constitute a term of study three months in length, with sessions two nights each week, and a tuition fee of $5. The course in pattern-making is similar in length and expense. The class in steam-engineering is instructed by lectures upon the physical properties of steam, methods of using it, construction of boilers and engines, methods of propulsion on sea and land, &c. The course is three months in length, sessions two evenings a week, and expense $10. The institute is supported by the income of productive funds and the

dues required of members. They are of five kinds, viz, members *in perpetuo* (with right of succession), who pay $50; life members, who pay $30; stockholders, paying $10 per share of stock and $2 a year tax thereon; annual subscribers at $3, and junior subscribers at $2 a year. Each department of work undertaken by the institute is controlled by a special committee, and has been carried on so as to meet the approval and gain the aid of substantial business men.

The University of Pennsylvania in 1872 created a special department of scientific instruction called the Towne Scientific School. Its design is to give a thorough technical and professional training in chemistry, with its manifold appliances to the industrial arts; metallurgy and assaying; mineralogy and geology; civil, mechanical, and mining engineering; mechanical drawing and architecture, and studies preparatory to a medical course. The completion of any of these courses requires five years. The first two years are devoted to a thorough training in preparatory and elementary mathematics, chemistry, and the methods of scientific research in general, and to instruction in history, English composition, rhetoric, modern languages, and mechanical and free hand drawing. At the close of these two years the student selects one of six parallel courses and devotes himself to the professional training they are intended to give. The course most frequently chosen is that in mechanical engineering. In it students are required to give particular attention to the cinematics of mechanism, the conditions under which work and power act, and the means of regulating them, the problems of hydraulics, and the mechanical theory of heat, with its application to the steam-engine. Weekly visits of inspection are made during two years to furnaces, foundries, machine-shops, and rolling-mills. Recent provision has been made for instruction in marine engineering and naval architecture. The faculty of the school is composed of 17 professors and 6 instructors and assistants. The students in attendance in 1881–'82 numbered 171. The museums, laboratories, and collections of apparatus are extensive and well adapted to their several purposes.

The School of Technology of Lehigh University, South Bethlehem, Pa., offers young men every needed facility for studying civil, mechanical, and mining engineering, metallurgy, and chemistry. The studies of the first year and a half are preliminary to the several technical courses. The course in civil engineering includes so much of mechanical engineering as is of direct service to the civil engineer, thorough instruction in geology and mineralogy, practical work, and visits of inspection to engineering undertakings in the Lehigh Valley and its vicinity. The course in mechanical engineering is accompanied by shop instruction, not necessarily involving manual labor and the manipulation of tools, but rather aiming to familiarize students with those points in pattern-making, moulding, forging, fitting, and furnishing which they need to know as designers of machinery. The object of study is the acquisition of the knowledge required by foremen and superintendents rather than manual dexterity and skill in the use of tools. The course in mining and metallurgy includes studies in those subjects necessary to all technical education, and in mining, metallurgy, geology, mineralogy, dynamics, qualitative and quantitative analysis, blowpipe analysis, topographical and mine surveying, and drawing. The full course occupies five years, though the student may take the degree of bachelor of metallurgy at the end of four years, which is the length of the other courses. The course in chemistry exhibits no peculiarities. The laboratories in which the practical work is done are said to be unsurpassed

in excellence by any in the country. Arrangements are made whereby graduate students may pursue advanced studies and after examination receive doctor's degrees. The university is so richly endowed that no tuition is charged, and many advantages are offered which would be beyond the means of poorer institutions.

Lewis College, Northfield, Vt., is the institution long known as Norwich University. It has but a small faculty and is not largely attended. The instruction is scientific and military in character, and of a grade comparing favorably with other scientific schools. The regulations of the college conform closely to those required by military usage.

The Virginia Military Institute, Lexington, Va., was organized in 1839 as a State military and scientific school on the basis of the United States Military Academy at West Point. In it is a special school of applied science, offering seven courses of study, the subjects being as follows: Architecture, civil engineering, machines, mining, metallurgy, analytical and applied chemistry, and agriculture.

The University of Virginia has no fixed course of prescribed study. Each student selects studies from its various schools. One of these is the Miller School of Agriculture, Zoölogy, and Botany. The studies in agriculture are either practical or scientific. The practical studies comprise the nature and formation of soils; their exposure and drainage; the best method of tillage; and the use of manures and fertilizers, and experiments to show their effects. Special instruction is given in the mechanical operations of the farm and in the management of teams. The scientific course comprises a review of what is known of the chemical composition of plants and the structure and functions of their organs, and of the atmosphere and soil, as related to vegetable production. The opportunities for studying the sciences are ample, and the chemical facilities are especially good. Degrees are conferred on students according to the kind and amount of their study.

After this summary of the work of our schools of science and industry, it is of interest to read the tribute paid to their efficiency by one of the directors of the Ohio Mechanics' Institute, in an address to the graduating class of 1880. He said:

> In the mechanic arts, and indeed in every department of busy practical life, the kind of training furnished by our industrial schools is of the highest importance, both to the industrial worker and the country at large; not only to the individual, by enabling him to command better prices for his work, but especially to the nation whose artisans are skilled workmen and whose productions secure prices in foreign markets and turn the balance of trade in its favor. The necessity for this special education was never so great in America as it is to-day. But a few years ago the United States contributed millions annually to the coffers of France and England in buying back as manufactured goods the very cotton our fields had grown, and, in the form of machinery and cutlery, the products of our ore banks.
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> * * * * * * * * *
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> But now the trade is changing. The fostering effect of our free institutions, which place the humblest workingman on an equal plane with the millionaire, the wise protection thrown by the national government around our struggling industries, and lastly, perhaps not least important, the elevating influence of our industrial training schools, these have worked a mighty change, which is heard in the increasing hum of busy spindles and clank of iron arms once more saluting the rising sun over all this broad land.
>
> The superiority of American design and workmanship has steadily and surely compelled recognition against every obstacle. * * * We are to-day competing successfully in the markets of the world with older and wealthier nations because we are able to produce articles, implements, and machinery either better in quality, superior in artistic and mechanical design, or better adapted to the purposes of their construction than the products of our competitors, and this is directly attributable to the superior intelligence of our industrial classes. We make better wares because our artisans bring a higher intelligence to bear upon their work.

Evidences of the advantages which have accrued to cities on account of the establishment of schools for technical education may be obtained from the history of places within our own country. Better illustrations are to be found in foreign nations. For example, a town of Saxony, Chemnitz, is teaching by indisputable arguments the value of industrial training. Once forests grew up around it, and coal beds there kept their wealth of fuel. Through it streams abounding in water privileges flowed undisturbed in their natural channel. Within it lived people possessing only moderate powers of mind and body. Consequently forest trees fell uselessly into decay, coal mines were scarcely opened, and the rivers spent their force on the rocks that hindered their descent.

The scene is changed. The town has been filled with schools of industry. In them mechanics, architecture, weaving, agriculture, trade, and miscellaneous industries, as well as "the general knowledge required in daily life," are being taught. The State Technical Educational Institution receives into its new home, which cost some $400,000 in 1877, more than 600 students, and trains them in the highest forms of labor. A hosiery school near by contributes to the success of that industry. The weaving school sent out recently 40 students as its semi-annual quota of trained weavers and dealers in woven fabrics. Mercantile and trade schools teach the duties and rights of merchants and the branches of knowledge which aid in the prosecution of business.

But are not these schools expensive, some one asks. Certainly. The town is taxed for their support and for its own growth more heavily than any city but one in Germany. Yet the burden is cheerfully borne, for the people have learned that the industrial training of their children is the fountain of their prosperity, and prefer elementary schools to prisons, trade and technical schools to workhouses and emigration, and school rates to poor rates. This willingness of the people to provide instruction and this eagerness to establish technical institutions are due to the development of industries, which have extended themselves as they were able to obtain trained workmen. Their growth is the growth of the city. Year by year they attract to themselves laboring men, and thus add to the population citizens contributing to permanent wealth. The number of inhabitants has more than doubled in a score of years.

The manufacturing cities of other countries are finding that their specialties are being produced cheaply and artistically in Chemnitz, and their trade thereby seriously impaired. Already Nottingham has yielded to it the front rank in the production and sale of gloves. America drew from its mills goods to the value of $4,500,000 in a single year of the last decade. Such is the prosperity of this city of schools. And when other cities, whether in Germany or England or America, adopt similar measures for training their citizens and extending the variety and improving the quality of their industrial products, then will they also meet with similar prosperity.

PREPARATION FOR INDUSTRIES A FEATURE OF KINDERGARTEN WORK.

The aim of Kindergarten training is to develop the child according to the natural law of its being. Baroness von Marenholtz-Bülow says:

> This is the kernel of Fröbel's method, that a way has been found to let the individual character of each one unfold itself in full freedom.

Fröbel himself remarks:

> We must launch the child from its birth into the free and all-sided use of all its powers. That is just the aim of these plays and occupations, which exercise the yet unseen powers of the nursling on every side. * * * Steadily, and during the whole era of childhood, body and mind should be exercised and cultivated together.

The statement of Bertha Meyer is that—

> Special talents find their opportunities better in the Kindergarten than elsewhere; for here the means of their development are presented in much greater abundance than in the family or anywhere else.

It is very often the case that this natural development discloses marked aptitudes for some industrial employment. Fröbel says:

> The faculty of drawing is as natural to the child as the faculty of speech.

This belief in the constructive tendencies of the child is revealed in his statement that—

> Man, the image of God, is, as such, a creative being; consequently the first principle of education is to make him capable of creativeness, able to create.

Miss Susan E. Blow gives especial emphasis to this outcome of Kindergarten methods when she says that—

> The aim of the Kindergarten is to strengthen and develop productive activity. * * * Hence the first use of the gifts is to waken, by their suggestiveness, the mind's sleeping thoughts, and the first use of the occupations to train the eye and the mind to be the ready servants of the will. While the child is still imitative in the occupations, he becomes inventive in the gifts; but as he grows to be more and more a law unto himself, he turns from the coercion of his blocks, tablets, and sticks, to obedient paper and clay, and, ultimately outgrowing the simpler occupations, concentrates his interest in the exercises of drawing, coloring, and modelling.

Respecting the need of such training as the Kindergarten aims to give, Fröbel says:

> When we ask for artistic industry, that our dignity may not be lost by the substitution of machine work, we find stiff and awkward fingers; we ask for a sense of beautiful form, harmony of colors, &c., in the workman, and find only dull eyes and senses, which cannot tell the crooked from the straight and know not how to put light and shadow in the right places. Indeed, when professional and art schools are opened for grown-up youth only, they cannot repair what was lost in childhood, let ever so much teaching be furnished. Technical skill must be given in early childhood if the human hand is not to be outdone by the machine, and the sense of beauty must be awakened in the soul in childhood if in later life he is to create the beautiful.

W. N. Hailmann, in his lecture on the specific use of the Kindergarten, speaks of its power to develop the artistic side of a child's nature thus:

> Æsthetically, the Kindergarten reveals to the child the wonderful beauties of color, form, and sound, and enables him to control them within the ever-expanding limits of his intellectual power; thus making him an artist as well as a discoverer and inventor, a poet as well as a worker and thinker.

To this statement of what the Kindergarten can do may be added a statement by Miss Blow of what the Kindergarten has done:

> In the Des Pères Kindergarten predestined engineers have built bridges as remarkable in conception as clever in execution; little mathematicians have discovered rather than learned all the simple relations of numbers; children with more than ordinary spiritual insight have intuitively seized the moral analogies of physical facts; tiny fingers have guided the pencil to trace beautiful decorative designs, and soft clay has been fashioned into flowers, fruits, and animals by the dextrous hands of embryo sculptors.

The preparation for industrial work afforded by the Kindergarten is ably discussed by Baroness von Marenholtz-Bülow, from whom the following is taken:

> As the whole method of Fröbel rests upon spontaneous activity and has for its aim to teach the formation and production of things, its first condition is to form the hand. * * * The hands of the child make their earliest apprenticeship to the art of giving form by digging into the earth and sand. To dig holes, to build houses and bridges, to give shape to the little dirt-pie by the help of mamma's thimble, to build castles with cards, and the Swiss cottage with pieces of wood; later, to make buildings out of pasteboard or to draw them on card-board—all this flows from that

instinct of transformation which is, properly speaking, the instinct of work. * * * This instinct is cherished and satisfied in the child-garden, where children build, make, and unmake in a thousand ways, and by means of every kind of material, always in the order indicated in the history of human development. Not only houses and tools are made, but also the hands are taught to weave and stitch. In weaving they make tissues similar to those fabricated by the inhabitants of New Zealand out of reeds and bark. Gradually the woven stuffs of our own times are reached. In learning to fold paper, in printing, pricking, cutting, not only skill necessary for making clothes is acquired, but that general dexterity which all manual labor demands. The hand is made ready for all those technical processes necessary to workmen in all professions as well as to those of which every one has need in practical life. At the same time the child is initiated early in industrial labor.

The facility with which children can acquire a familiarity with many industrial arts is well presented in a circular just issued by this office entitled "Industrial Art in Schools," by Charles G. Leland, of Philadelphia.

INDUSTRIAL WORK IN EVENING SCHOOLS.

Evening schools are emphatically for the working people. The wealthy have either received an education in their early years or have gained the training they desire by actual contact with men and things while accumulating and caring for their property. Their children are not driven to the necessity of devoting their evening hours to preparation for coming life. It is only the hope of a future prosperity, to be gained in no other way, that induces any one to call the currents of life away from the refreshment of the weary body to the solution of problems which contribute only indirectly and after long waiting to comfort and happiness. The studies of these schools are not usually directed to the immediate preparation of a workman for his trade. In this sense they have not often been industrial. In a wider sense they have been; for the faithful pursuit of even the simplest studies awakens that within a man which augments his value and capacity as a worker. Many years ago a clergyman, reporting on evening schools in a manufacturing city of New England, said:

> The effect of only a little education has been an increase of self-respect, a quickening of the powers of action, a management of the physical powers to more advantage, an easier triumph over difficulties, an increase of skill and production. From the mills and work-shops of the city frequent testimony to this point has been proffered us.

A mechanic in New York City, who had accomplished so much in his trade as to have received a medal at the Paris Exposition of 1878, in a recent letter to this office refers to the starting point in his career as a thinking and educated workman as follows:

> After serving my apprenticeship and working three years as a journeyman smith, I began to feel how ignorant I was, and how much I stood in need of culture and other matters which could only be gained through an education. And to lift myself out of this mediocre mine in which I had so long remained I attended night school twenty-eight nights at one of the public schools of this city, at which I mastered reading, writing, arithmetic, and book-keeping, single and double entry. Since that time I have been an ardent student.

Such results as these have come from the quiet elevating and dignifying of men and women through the pursuit of elementary and general studies. By the introduction of drawing and other subjects pertaining directly to an industrial education even more has been accomplished for artisans. They now take studies which prepare them for the better execution of their work. The report of the evening high school of New York City, 1877, says:

> In most cases they (the pupils) attend in order to acquire that knowledge which they deem desirable and even necessary to enable them to pursue their various avocations with skill and intelligence.

The report for 1881, expressing the same truth, says:

> Almost every industry of our city is here represented by those who are seeking that particular instruction the attainment of which will qualify them to perform more skillfully and in a more satisfactory manner the duties of their several vocations.

The large number of evening pupils who choose drawing, when such a choice is allowed, indicates that the working classes are coming to understand its importance and to agree with those who give it a prominent place in education, and who estimate its value, as did General J. C. Palfrey when he wrote the following sentences:

> A knowledge of mechanical drawing is invaluable to all constructors, whether employers or employed, and of constant use in ordinary affairs. In all matters of construction, in the widest sense of the word, it takes the place of a knowledge of reading and writing in the other concerns of life, and is indispensable for giving and receiving intelligible ideas. A mechanic who is without it will almost always be subservient and inferior to one who has it, but is his inferior in all other respects. A man rarely becomes a competent master mechanic without some knowledge of it. It affords means of representing any combinations of forms with such accuracy and minuteness as to convey as clear an idea of the thing represented as the thing itself could if present to the senses, and thereby saves the delay and expense of experimental or tentative constructions, and the inconvenience or impossibility of using the thing itself for explanation or examination. It is the only way of directing one's own or others' labor in construction exactly to any desired result.

It is the place of evening schools to continue the work of the day schools, not only in drawing and other industrial directions, but also in imparting the fundamental studies of a general education. Many working people are unwilling to keep their children in school even during the time when attendance is compulsory. The small earnings which might be gained before a child is fourteen years of age, which is commonly the time when compulsory school laws allow children to leave school, seem too valuable to be lost or sacrificed to the requirements of the school-room. In Connecticut, in 1873, about 2,250 children under fourteen years of age were reported as kept from school to work. In New Jersey in 1880, while only 4 per cent. of the children between 10 and 11 enrolled in the census were out of school, the per cent. increased to 20 for those between 12 and 13, and to 67 for those between 14 and 15. So fixed are poor parents in the idea that their children must commence work at the earliest possible moment and so often does necessity compel this that it is doubtless true, as Mr. Huxley asserted of England:

> That no scheme of technical education is likely to be seriously entertained which will delay the entrance of boys into working life or prevent them from contributing to their own support as early as they do at present.

However this may be, it is certain that the sons and often the daughters of the people who labor in our factories generally commence work soon after they arrive at the age when they are not compelled to attend school. Often their hours of labor are so many that little time is left for evening study. Doubtless many have not strength to labor and study at the same time. Yet it may be assumed that the cases of injury from overstudy at night are fewer than the instances of moral and physical injury received in evening hours upon the street or in the haunts of vice. When at length a pupil is found who possesses strength and ability to combine faithful and efficient work during the day with intelligent study at night, he is worthy of higher education. He has passed a test that would have shown any serious obstacles to progress in his trade, and enables his superiors to forecast the probabilities of his final success. He has acquired a practical knowledge of the matters which his technical studies would explain and illustrate, and thereby

can pursue them to the best advantage. The gain obtained in this way is of great value. The keeper of the mining-records at the Royal School of Mines of England once said:

> If I could do it, no man should attend the school in Jermyn street (the school of mines) until he had worked three years under ground, so satisfied am I of the necessity of combining practical knowledge with scientific acquirement.

The technical school in Chemnitz, Saxony, which has hundreds of pupils studying the arts of milling, dyeing, tanning, and manufacturing, requires that each student shall have worked two years at his occupation before admission to the school, and attended an evening school during his years of actual work. An eminent writer, himself an advocate of ideas similar to those mentioned, commends such a course of education as should give a youth, first, instruction tending to strengthen his body, elevate his morals, and cultivate his intelligence; second, a period of actual service in a shop; and lastly, if deserved, a superior special training. In such a scheme for technical training, evening study must hold an invaluable place as the means by which the mind is kept fresh and mobile during the time employed in manual labor.

If such a method of growing toward and into leading places in industrial pursuits is best for the poor, it is also for the rich. And would it not be well for our industries, would it not contribute to the solution of social problems, might it not also benefit our young men themselves, if people of wealth could be led to believe that it is good for their children to bear the yoke in their youth, to be inured to such labors as workmen in our factories perform, to show by open competition their capacity and efficiency, and then to be educated for that branch of industry for which they have shown special aptitude?

As has been intimated, the actual instruction afforded by evening schools is chiefly in the most elementary branches; some introduce higher studies, and a few may be said to give industrial instruction, usually in the form of lessons in drawing. A brief statement of the attendance and studies in some of them indicates the bearing of these schools on industrial education. The evening high school in New York City during the winter of 1879–'80 had an average attendance of 1,054 pupils, of ages varying from fourteen to forty-seven. Among the studies pursued were freehand, architectural, and mechanical drawing, chemistry, and phonography. It is authoritatively stated that a large and deserving class of men are receiving the benefits of this school.

In two of the evening schools of Saint Louis, at which there was an average attendance in 1879–'80 of nearly 200, "the branches taught are such as form an elementary course in polytechnic studies."

Although the practical benefits derived from evening schools in general are questioned by school authorities in many of the cities in which they have been maintained, the value of evening drawing schools is almost invariably admitted and urged.

In Cambridge, Mass., while the results of the ordinary evening schools in 1878–'79 scarcely warranted their continuance, the drawing schools furnished a most favorable report. One of the two schools gave instruction in mechanical and the other in freehand drawing. The former was largely composed of those already engaged or about to engage in mechanical pursuits, and represented fourteen callings. Carpenters, cabinet-makers, and machinists predominated. The subjects of instruction were geometrical drawing, orthographic projection, and building construction. The principal subject studied by the class in freehand drawing was industrial design.

In 1879–'80 there were six evening drawing schools in Boston, having seventeen instructors and an average attendance of 299, of whom 235 were males and 64 females. The usual number of sessions was 80 or 81. A plan of a two years' course in industrial drawing was arranged and adopted. The first year's instruction is general and elementary and for all students.

In the second year there is a choice of four courses, viz (1) freehand design; (2) machine drawing; (3) building construction; (4) ship drawing. Applicants being over 15 years of age are admitted to the first year's course without examination. For entrance upon the freehand course of the second year students are examined in drawing from the object; for entrance upon the instrumental courses, in plain geometry. Classes are open three evenings each week from 7½ to 9½, and students are required to sign an agreement to attend the whole session, punctually and regularly, unless prevented by sickness or removal.

Says a Boston newspaper:

> One of the most gratifying features of this branch of our public education is that so many of the pupils are able to apply what they have been taught, both as a direct means and as an important aid in the acquisition of a livelihood. The manner in which one or more individuals have received a practical benefit from their public instruction in drawing has been brought to the attention, some time or other, of a majority of persons in the community. These cases are but types of a large body of workers in the same direction—a body whose numbers are rapidly increasing, and who have already exerted a positive moral and commercial influence among us. It is now not unusual for an employer to require of certain of his employés, as a prerequisite to an engagement, more or less familiarity with drawing, such as can be acquired in the evening schools. This, in some instances, is the case in the so-called purely mechanical occupations. More than this, it is frequently part of an apprentice's contract, in such trades as wood-carving, fresco painting, and the like, for him to attend some drawing school in the evening.

The superintendent of schools of Springfield, Mass., speaks of the success of the evening drawing school of that city during 1881 as follows:

> This school has had an enrollment this term of 185, the largest number ever in attendance in one year. The steady patronage given to the school, year after year, is gratifying evidence of the practical work done there and of the estimation in which such a school is held by those who are willing, after laboring during the day, to devote their evenings to improvement in a branch which is so highly beneficial in increasing their preparation for better work in their several callings.

The superintendent of public schools of Worcester, Mass., made the following response to an inquiry about the evening drawing schools of that city:

> The course of study in the evening drawing schools consists of beginners' and advanced classes in both free-hand and instrumental drawing. The students are young men and women for the most part engaged in mechanical or artistic callings or in teaching. In the advanced classes they are employed in construction, in the mechanical drawing and in drawing from the life in free-hand. All the students in these classes are earnest and industrious. There is no time wasted, no nonsense, and no unnecessary absence.

The following classes, open to both sexes, are proposed for the winter of 1882–'83. Each class will be formed in case twenty applicants appear:

> Advanced free-hand drawing (class No. 1) for those who have had previous instruction. This class will draw from models and imported casts. The facilities for the study of figure and form from the valuable collection of casts are excellent.
>
> A course in free-hand drawing for beginners (class No. 2). Instruction will be given from the blackboard in outline, principles of design, perspective, and elementary model-drawing, and in copying from imported examples of ornament and figure.
>
> A course of instrumental drawing for beginners (class No. 3). The instruction will

include the elements of plane geometry, the principles of plane projection, intersection of surfaces, &c.

Advanced course of instrumental drawing for machinists and iron-workers (class No. 4). This class will make working drawings of machinery. The work will be so arranged as to include all the processes and principles involved in making plans, elevations, and sections of combinations, and details, including coloring and lettering.

Advanced course in instrumental drawing for carpenters and wood-workers (class No. 5). This class will make details, working drawings, scale drawings, and elevations of a modern dwelling-house, store-front, or something similar. Attention will be given to coloring, lettering, and finishing the drawings. Instruction will be given from the blackboard and from practical working drawings used in the construction of buildings already put up or in process of construction.

The Technical School for Carriage Mechanics holds its sessions in connection with those of the art schools of the Metropolitan Museum, at 214 East Thirty-fourth street, New York City. It has been in operation over two years and has met with a good degree of success. The attendance has increased, and even distant portions of the country are now represented in the attendance. Drawing is the principal study. Lectures on subjects connected with carriage building are given, and a library is being collected. The annual report of the committee of the carriage builders' association on technical education, given in Appendix C, presents additional information respecting this school.

In connection with this effort the work of Mr. J. L. H. Mosier with the boys in the carriage factory of Brewster & Co., in New York, may be noted. He had acquired a good education in practical directions by improving his leisure time and was anxious to help others to advance by the same road over which he had come. Consequently he has been accustomed to encourage the workmen intrusted to him to read and study by gaining them admission to libraries, loaning books, and urging them to attend evening schools. Later he has gathered the boys in his office during the noon hour, given them reading matter relating to their trade, instructed them in elementary book-keeping, and in parliamentary rules and practice, and given copies for writing and drawing to be done at home. In this way the education which most of the boys received in their younger days in the public schools is put into use and increased, and their spare hours are made to contribute, not to their injury, but to their moral and intellectual progress and to their capacity as workmen. A short account of this peculiarly commendable effort from Mr. Mosier himself is given in Appendix C.

Other educational efforts in behalf of carriage builders have been made by Mr. J. Polya, in New York City (1295 Broadway), and Mr. George A. Hubbard, in New Haven. The latter gentleman has presented such a full account of his work that it has seemed best to present it nearly in full in Appendix C. It is a most noticeable statement, and should be read by all interested in industrial education. Mr. Polya's school is entitled "A Drawing School for Body-makers." It is open three evenings a week from 7.30 to 9.30, for five months. Its object is to teach the application of geometrical principles to the construction of carriages, with a special view to economy of labor and material. Problems are drawn on a blackboard, explained to the class, and copied by them. Each scholar is also given exercises on the blackboard. The school is conducted after a French model, the history of which Mr. Polya gives substantially as follows: The first school of this kind was established in Paris, France, in 1839, by Mr. Fablot, a body-maker. It was abandoned several times in subsequent years because it was not a financial success. In 1872 it was reopened by the Paris Carriage-makers' Mutual Benefit Society, and received the promise of a yearly bounty of 2,000 francs from the local government. The monthly

dues were placed at three francs. Five lessons a week at seven o'clock in the evening were given. In the succeeding years the attendance grew to be so large that many of the applicants could not be received. Consequently another similar school was established in 1878 by the Carriage-Builders' Association. Both the schools are said to be successful.

Among the evening schools imparting industrial training may be mentioned the night school of art, Cooper Union, New York City, the Trenton (N. J.) Art School, and the schools of art and design of the Maryland Institute, Baltimore, Md. The first of these has been mentioned; the second, the Trenton Art School, was begun in October, 1879, by the master potters of that city for the purpose of giving apprentices opportunities of educating the eye to appreciate form and color and the hand to imitate. The school is open two evenings each week from 7.15 to 9 p. m., and has an enrollment of from 30 to 35. On account of the deficiencies of the pupils in acquirements in drawing, the instruction begins with elementary drawing, and is adapted to the increasing skill of the student. Classes in painting and modelling will be established as required. The progress thus far has been satisfactory, although the lack of copies is a considerable hindrance.

The schools of art and of design of the Maryland Institute have for the last thirty years been attended by an average of 417 students each year. Its managers, who are mainly engaged in the industries, and therefore interested in their development, have devoted time and energy to perfecting and enlarging the sphere of its educational operations.

The night school of design is especially intended for the adult industrial class. It is open three evenings each week from the middle of November to the middle of April, and provides a full course of elementary, artistic, industrial, mechanical, and architectural drawing. Premiums amounting to $500 annually are given to the seven students of highest rank.

Some of the leading art schools maintain evening classes in addition to their usual work; for example, the school of design of the Cincinnati University has classes from 7 to 9 p. m., as follows: wood-carving on Tuesday, Thursday, and Saturday; sculpture on Monday, Wednesday, and Saturday; pen-drawing on Thursday; drawing on Tuesday, Thursday, and Friday; decorative design on Monday and Wednesday. The Metropolitan Museum of Art in New York City maintains evening classes in (1) modelling and carving, (2) drawing and designing (instrumental and perspective, and technical), and (3) carriage drawing and construction. A nominal tuition fee is charged (from $8 to $15 a season). This pays for materials and models, and "has so far secured a superior class of intelligent workmen and students, thoroughly in earnest in practical or artistic improvement."

MISCELLANEOUS PROVISION FOR TECHNICAL TRAINING.

There are several schools of an industrial nature which are not included in the classes of which mention has been made. Their organization and methods of instruction are unlike those of other institutions and are, therefore, rich in suggestion to those seeking new channels through which industrial training may be carried to the people.

An attempt to connect shop work with the studies of the public schools was made at Gloucester, Mass., a few years since. A lady placed several hundred dollars at the disposal of the school committee to be expended for the industrial education of boys. A shop was fitted up with

benches to accommodate twelve workmen; and, in addition to the fixtures belonging with the bench, the following set of tools was furnished: a rule, try-square, hammer, jack-plane, jointer, smoothing-plane, bit-stock, bit, mortise-gauge, mallet, a one-half-inch mortising-chisel, a one-and-one-quarter-inch paring-chisel, chalk-reel, rip-saw, panel-saw, screw-driver, brad-awl, oil-can, oil-stone, bench-hook. The shop course was divided into forty lessons. The names and uses of the tools are first learned. Afterward the pupils are instructed in their use, and eventually taught box-making. The lessons were at first given on Saturdays; as the novelty wore off, the pupils wearied of giving their holiday time to shop work, and a change of plan was necessitated. The industrial department as it existed after the changes were made is described by Mr. L. H. Marvel, then city superintendent, as follows:

In October, 1880, arrangements were made to accommodate pupils in the carpentry class one-half of each afternoon session on Monday, Tuesday, Thursday, and Friday of every week (two classes each session). By this change regularity and punctuality in attendance have been secured; and from a membership of thirty pupils, in three classes, there was an immediate advance to a membership of ninety-six in eight classes, each receiving one hour per week. A few girls (six) were permitted to join one of the classes in 1878. There are now two full classes of girls, and there is one class composed partly of each sex. The work of the girls is equally as good as that of the boys, and they seem to enjoy it heartily. The attendance is entirely optional, nearly one-half the pupils in the first and second classes of the two larger grammar schools desiring to attend. There is no compulsion whatever, except that, while members of the industrial class, the pupils are required to be as attentive, industrious, and orderly as during any portion of their school work. There has been a training in the nature of the implements used, in the best methods of employing those implements, constant attention to those habits of method and system which are necessary to secure good work anywhere, and continued practice of the hand and eye in unison, requiring close application as well as clear perception and accurate manipulation. The result is tangible, and the proficiency is measured by no arbitrary standard of percentages, but is clearly defined, and may be estimated with much more precision than in any other line of school work. I do not know of any manner in which fifty to eighty hours can be employed in any form of education where the practical results can be more satisfactorily determined. If the pupil never sees saw, hammer, or plane again, the training he has received will be of value, whatever his vocation.

The Miller Manual Labor School, Batesville, Albemarle County, Va., is an institution recently organized for the purpose of affording poor children an opportunity to obtain a practical education. It was founded by the late Samuel Miller, who bequeathed the greater part of a princely fortune to trustees for its creation and endowment. The will was contested, and it was several years before the executor was enabled to transfer to the trustees the property designed for the school. An act of compromise was passed by the legislature in 1874, and in accordance with its provisions stock, bonds, and property, amounting to over $1,000,000, were put in the hands of the proper officers. The work of preparation was commenced in 1876. A building, costing $100,000, was erected the subsequent year, which realized the intention of the donor to have accommodations at once provided for one hundred pupils and their teachers. The first pupils were received in the fall of 1878; now there are over one hundred in attendance. The number of pupils is not limited, except by the sufficiency of the income to pay their expenses, not only for tuition, but also for board, clothes, medical attendance, and "everything incident to and connected with the school." The instruction is to be in "all the branches of a good, plain, sound English education, the various languages (both ancient and modern), agriculture, and the useful arts." A superintendent and four teachers are engaged in the work of supervision and instruction.

Manual labor is required of all the pupils in several departments of industry. Carpentry, printing, telegraphy, farming, and gardening are

already introduced. An extensive machine-shop is being built. In it practical training will be had in wood and iron working. The farm connected with the school consists of 600 acres of land. It has good buildings, and is being stocked with the best animals procurable. An orchard, a vineyard, and a garden are furnishing opportunities for work and instruction.

Efforts have been made to introduce elementary manual training into the public schools of Boston. In 1879 the subject was brought before the city council by a petition from intelligent and influential citizens. The matter was referred to the school committee. They appointed a select committee to consider the question and report upon it. This committee thought that a free industrial institute should be established consisting of a developing school and school shops, to be supported by the city, at least in part, and permanently ingrafted on our school system. The proposition was not sustained by the city council, but the friends of the project considered it postponed rather than defeated. The prevailing opinion of the school committee is expressed in their report for 1881, as follows:

> The school committee has again repeated its formal vote of desire to test the feasibility of imparting to grammar scholars some of the elements of mechanical skill, by whose final application so many of them must, by and by, earn their daily bread. The term industry, as applied to manual labor, is far too large to be adequately comprehended under any use of carpenter's, machinist's, or blacksmith's tools. These are but portions of a vast field, which only a great number of special schools could make any pretension of properly traversing. But it is possible to meet some of the complaints which are so frequent that the public education is so exclusively intellectual as to unfit the majority of youth from entering heartily into the ranks of manual labor, by directing certain pursuits of the school hour to the especial end of training the hand and the eye, so that whatever the future occupation of the child, he shall not be utterly awkward and helpless in the every-day responsibilities of earning his living. Education may and ought to help youth to be self-reliant and handy, as a mere bookish student is not likely to be.
>
> The eminent success of the sewing instruction in the girls' school, a branch of school work for a long time looked upon with great distrust by most persons who had given any thought to matters of education, has afforded convincing evidence that it is possible to impart special manual skill without interfering with the established routine of study. The teaching of industrial drawing, now pretty firmly seated among the essentials of instruction, is quite within the line of training for the practical life of the manual worker; and so those who have watched the shop work of the Massachusetts Institute of Technology and the smaller experiment of the Boston Industrial School Association in teaching boys the manipulations of a few varieties of mechanics' tools (from which training some have been known to go into successful positions in trades) have continued to feel, notwithstanding the disapproval of their plans by the money-appropriating authorities, that it would be no unwise venture to devote a small portion of the week in a few boys' grammar schools to an experiment of using hammers, saws, chisels, and like tools, under a competent instructor, with the design of enlarging the work as fast as its smaller operations should be shown to be of advantage.

In the Boston Industrial School a course of 24 lessons in wood-carving was taught in such a manner as to afford the greatest amount of instruction and involve the least possible expenditure. The lessons were given from 7 to 9 o'clock on two evenings of each week. The tools used were the flat chisel, the gouge, and the veining tool. Smooth blocks of white wood, 6 inches long, 2 or 3 broad, and 1½ thick, were the material used. Specific articles were not made. Manipulations common to leading wood-working trades were taught. The school proved the practicability and value of doing this, and thus has become a foundation in fact for arguments in favor of giving youth instruction of the kind imparted by it during its existence. Rev. George L. Chaney, the president of the association which had the school in charge, says:

A single ward-room like the one used by the school in Church street, in any city, for the six months from December to May, during which time it usually lies idle, with very little expense beyond the original plant and a moderate salary to the teacher, would meet all the needs of three or four of the largest grammar-schools for boys.

Three such supplementary schools, if used in turn, would amply satisfy all the rightful claims of industrial education of this kind upon the school system of such a city as Boston. At so small an outlay of attention and money might the native aptitude of American youth for manual skill be turned into useful channels. In so simple a way might the needed check be given to that exclusive tendency toward clerical rather than industrial pursuits, which the present school course undoubtedly promotes.

The organized charities of Boston have used their influence in favor of the introduction of manual instruction into the public schools by the appointment of a committee on industrial training and the publication of its report, in which five articles of belief were presented. The substance of them is as follows: First, industrial training is the proper complement of a literary education, and as such should be adopted as a part of the public school system; second, public industrial training should be general, not special; third, education, not production, should be sought; fourth, elementary training might commence in the primary school and be continued through the higher grades; fifth, such training is feasible and not unwarrantably expensive.

The co-operation of the people of Boston and the inducements offered by the Industrial School Association have at length enabled the school committee to make a practical trial of a shop in connection with a public school. One of the rooms of the Dwight school building was fitted up for the purpose. A carpenter was employed as teacher. The session continued from January to May, 1882. The total expenses incurred in equipping and continuing the shop were $712. A report of the success of the enterprise was made by James A. Page, principal of the Dwight school, soon after the close of the session. From it the following extract is taken:

On the first Thursday of January the instructor gave his opening lesson to a class of eighteen boys, all who could be accommodated at the three benches at one time. These boys had been selected by myself from the graduating class, without reference to their standing, and no conditions were made with them except that they should not fall behind in their regular school-work. Another class of the same number was selected from the second, third, and fourth classes, in order that the experiment might be tested by a wider application to ordinary grammar-school material. Many of these latter had already handled tools, to a certain extent, either at home or in their fathers' work-shops.

In arranging the practical details of the school with Mr. Bachelder it had been agreed that school discipline should be maintained throughout the sessions; that the programme should be carefully written out on the blackboard; that each boy should be marked on the work done, and that a record of it should be kept. All this was faithfully carried out, and contributed, as I think, largely to the final success. From this beginning to the close the school went on with unbroken and successful regularity. The teacher was promptly on hand; the order was good; the pupils interested.

It was delightful to see the eager desire manifested everywhere in the room to do the day's work well. There was no absence, no tardiness. On one occasion a count was made, and seventeen out of eighteen pupils were found at work at one o'clock when two was the hour for beginning. It was feared that the noise of many hammers and other tools in use at once (as was necessary in giving the same lesson to a whole class) would be so great that the other rooms on the same floor might be seriously disturbed. It was arranged, therefore, that the school in the adjoining room should proceed to the hall whenever a lesson in the training-room was going on. Practically, however, no trouble was felt from this source. The walls in the school-room were found to be so thick as to deaden the sound almost completely. It was thought also that taking a part of a class away from its regular school-work would result in more or less detriment to its progress in the prescribed studies. Here and there a complaint was made by the teacher of some second class boy, that he was not doing his work well in his own room; but the pupil, in every case, was so anxious to

remain in the "carpenter's class" that a word or two of warning was sufficient to bring his performance up to the standard again.

* * * * * * *

I consider that the results go far to prove that manual training is so great a relief to the iteration of school-work that it is a positive benefit, rather than a detriment, to the course in the other studies.

Immediately in this line are the recommendations of the committee on industrial education of the American Institute of Instruction presented at the meeting of the institute in July last. They are the following:

First. The introduction into schools of broader provisions than now exist for the development of the sense of perception of pupils in regard to color, form, proportion, &c., by contact with models and with natural objects.

Second. The more general introduction into schools of simple physical and chemical experiments, for the purpose of acquainting pupils through observation with the elements of chemical and physical science and their application in the arts.

Third. The teaching of drawing, not as an accomplishment, but as a language for the graphic presentation of the facts of forms and of objects, for the representation of the appearance of objects, and also as a means of developing taste in industrial design.

Fourth. The introduction into schools of instruction in the use of tools, not for application in any particular trade, but for developing skill of hand in the fundamental manipulations connected with the industrial arts, and also as a means of mental development.

A recent paper by Prof. H. H. Straight, of the Oswego (N. Y.) State Normal School, contains many practical and well-digested thoughts on industrial education and the public schools. The following elements are given by him as necessary to a person educated industrially:

(1.) An industrial disposition, which leads to a cheerful and even happy devotion to some chosen employment as the avenue through which to make his contribution to the world's wealth.

(2.) Industrial knowledge—such general and special knowledge as will put him in possession of the best human experience in the direction of his chosen vocation.

(3.) Industrial power—such development of physical, intellectual, and artistic power as will remove as far as possible the chances of failure, and, by giving a just consciousness of strength, will enable him to work always with the hope and expectation of success.

The means by which Professor Straight would have the public schools develop this industrial power are the following:

(*a.*) *Physical power*—They must take the best physiological knowledge the age affords, and under its guidance develop a body capable of enduring all the strains and fatigues likely to be brought upon it by at least the ordinary exigencies of life.

(*b.*) *Intellectual power*—They must impart the knowledge which it is their duty to give according to the laws of mental assimilation, as discovered and interpreted by the best students of mental growth, to the end that mental dyspepsia may be avoided, and that the best intellectual conditions may exist for the quick and accurate solution of at least the ordinary problems of life.

(*c.*) They must give such a development of the sense of the beautiful as will enable our people not simply to enjoy the beautiful in the objects about them, but such as will give a *finesse* and finish to whatever work they undertake, whether it be the culture of corn, the making of a coat, the building of a house, or the painting of a picture. Every workman should have, to the largest possible degree, the fine feeling of the artist, while every artist should be recognized as a working man.

This basis for special industrial training is to be obtained by associating materials, forms, and processes with the common studies of the public school. A workshop may be equipped at small expense in which considerable may be accomplished. What might be gained by an industrial course involving only inexpensive illustrations and aids, and carrying out the principles stated, is summed up as follows:

(1.) The cultivation of observation and judgment, the discipline of hand and eye, obtained in this way, would not be second to that obtained in any other way.

(2.) The course in mathematics, together with the course in language and geography, could be made the means of acqainting them with those natural products and forces which underlie all industries and all arts.

(3.) They would learn in a general but efficient manner the fundamental industrial processes which underlie the more special processes of the common arts.

(4.) This general but genuine knowledge of materials, forces, and processes will enable each student to choose, with a fair degree of intelligence, the industry for which he or she is fitted by special taste and power.

(5.) Such a course would make far easier than now the change from one occupation to another, which must ever remain an incident of growing industries.

(6.) It would give to each person, as employer, some power to judge of the work of the employed.

(7.) It would furnish a basis in intelligence for general sympathy and appreciation among different classes of workers.

(8.) The last and greatest good would be the cultivation of the industrial disposition. * * *

SECTION 3.

*INDUSTRIAL AND SCIENTIFIC EDUCATION OF WOMAN.**

The education of woman in science, arts, and industries is undertaken by many of our schools of science and agricultural colleges. Following the example of ordinary colleges and universities, more than half of which extend equal advantages to both sexes, the institutions endowed by the nation for the practical education of the people have generally afforded women the benefits of the instruction given men and frequently have provided special training for them in spheres peculiarly their own. The institutions of this class which are not known to admit women are the State Agricultural and Mechanical College of Alabama, the Georgia State College of Agriculture and Mechanic Arts, the Southwest Georgia Agricultural College, the South Georgia College of Agriculture and the Mechanic Arts, the Louisiana State University and Agricultural and Mechanical College, Maryland Agricultural College, Alcorn Agricultural and Mechanical College (Mississippi), Agricultural and Mechanical College of the State of Mississippi, New Hampshire College of Agriculture and the Mechanic Arts, Rutgers Scientific School, Agricultural and Mechanical College (University of North Carolina), agricultural and scientific department of Brown University, South Carolina College of Agriculture and the Mechanic Arts, University of Tennessee and State Agricultural College, State Agricultural and Mechanical College of Texas, Virginia Agricultural and Mechanical College, and agricultural department of West Virginia University.

The greater portion of the remaining agricultural colleges open their recitation-rooms, lecture-rooms, museums, libraries, and laboratories alike to men and women. There may be minute differences in the regulations under which the sexes come, but they are not sufficiently important to be mentioned in the reports and catalogues of the individual institutions, and therefore are hardly worthy of general notice. A few colleges and universities understand the full needs of woman's practical education and have felt themselves able to undertake it. Older countries have deemed it necessary to give such instruction. The making of garments, the economical management of the household, and the care of the sick are among the home industries that have been taught in special schools. Mr. J. Scott Russell gives special prominence to fire, food, clothes, and health as subjects for woman's study. After discuss-

* The material for this Report was originally collected in conformity to a Senate Resolution introduced by Senator Morgan, of Alabama. That resolution made special mention of efforts for the industrial education of women. Consequently much attention has been given to that subject in preparing this document.

ing the need of instruction in them and other subjects of kindred utility, he says:

It is for the woman whose husband works hard to earn money that I propose this special and superior education to enable her to spare and spend his money as well and wisely as he earns it. It is most necessary for the poor man's wife to know the value of money and the nature of money's worth. The cost, value, and wise way of using fuel is to her and hers a first need. The first principles of cookery are to her vital conditions of existence. She, above all, should know how to select good food, to cook it wholesomely and nutritiously, to mix good drinks, to buy cheaply, and to get good measure and exact quantities of all she wants; to make all her markets wisely and well; to buy all of the best, and all at a moderate price; that is her special wisdom. How to clothe her children, her husband, and herself with good, lasting, warm stuffs; to select them herself, to cut them herself, to sew them herself—there is occupation, enjoyment, virtuous work. Then to be able to teach her children all she knows; to be able to train them to be wise, virtuous, and useful like herself—there is work and also happiness; and then to be able to receive from them grateful help in return—there is reward. Then look at the poor man's leisure in a home illuminated by such an educated woman; look at an evening fireside where books can be interestingly and well read aloud; where songs can be sung correctly and well in parts in which all can join; where stories can be well told and games of intelligence played, and where each can benefit by another's knowledge. See how the evils and gloom of a humble lot vanish before the sunshine of an educated mother's home organization. It is to the poor man that the educated wife is the great prize of life.

The efforts which are being made for the technical and industrial education of women, not only in agricultural colleges but also in all other institutions in which they are being practically trained, may be combined under the following heads:

(1.) The opportunities afforded them for general scientific training.

(2.) The instruction given in art which, though often intended only to give the pupil a valuable accomplishment, may be utilized for the purposes of earning a livelihood.

(3.) Instruction in sewing, dress-making, millinery, and kindred pursuits.

(4.) Instruction in household economy; that is, in subjects pertaining to the health and comfort of the family, including kitchen garden training, cookery, and nurse training.

(5.) Instruction in special industries, such as telegraphy, phonography horticulture, wood and other engraving, decorative work, wood carving' lace work, designing textile fabrics, lithography, photography, and other related occupations.

THE EDUCATION OF WOMAN IN SCIENCE.

Universities and colleges furnish scientific instruction, either incorporated in a classical or literary course, or brought into a distinct course, or in both these ways. The general work of the distinctively scientific schools is given at length elsewhere, and the facilities they offer to women may be seen by referring to the accounts of the various schools. But there are special schools which call for notice in this connection.

Fifty-one courses of study, each constituting a full collegiate curriculum, are offered by professors and other instructors in Harvard College to those who pass the Harvard examinations for women. The number availing themselves of some or all of these courses is not large. The instruction afforded is well adapted to make highly educated teachers and specialists of those who are long in attendance.

Summer institutes are held in many places, and in some of them scientific and practical education receives prominent attention. The Martha's Vineyard [Mass.] Summer Institute in 1879 had courses in botany, zoölogy, geology, and mineralogy, in industrial drawing, and in

phonography among the considerable number which it offered. There were about 170 students in attendance.

Scientific training in the majority of the institutions for the higher education of women is confined to the most elementary instruction in a few of the most prominent branches. Some of these institutions having the funds requisite to the furnishing of appliances illustrative of scientific studies, and patrons who demand such a course of study for their daughters, offer extended instruction, supplemented by laboratory practice and illustrated by the best apparatus in use. A few institutions only will be needed to represent this latter class. Rockford Seminary, Rockford, Ill., offers a scientific course, in which, in the first year, physiology and hygiene and botany are taken; in the second year, physics; in the third year, chemistry; in the fourth year, geology. The means of practice and illustration comprise a chemical laboratory, physical apparatus, a valuable herbarium, and cabinets of geology, mineralogy, etc.

The collegiate course of Milwaukee College (which is for women) gives prominence to scientific subjects, and the appliances in this direction include a finely equipped observatory; physical and chemical laboratories, each having special reference libraries; apparatus designed not only to illustrate, but to encourage investigation; and cabinets representing five branches of natural history. Original investigation is made the objective point toward which every student labors throughout the course.

A statement respecting the scientific instruction given in Wellesley College (Massachusetts) in 1880 has been furnished, and will be found in Appendix E.

Smith College, Northampton, Mass., and Vassar College, Poughkeepsie, N. Y., may be taken as the typical institutions providing the highest general education for women. Smith College has an extended course of study covering four years, equal in character and scope to that of the university as understood in this country. It employs a staff of 22 professors and teachers, accords degrees on graduation, and includes, besides the higher English branches of polite education, studies in Latin, Greek, German (early and modern), French, Anglo-Saxon (early English), mathematics, geometry, calculus, theoretical surveying, navigation, and astronomy. The scientific studies include chemistry (with laboratory work), geology, mineralogy, physiology, psychology, zoölogy, botany, and biology. The art courses embrace music, drawing, painting, modelling, with lectures on architecture, sculpture, art, and household decoration.

Besides general studies the courses at Vassar embrace the Greek, Latin, German, and French languages; in mathematics, geometry, calculus, surveying, navigation, and astronomy, with the use of observatory; in science, chemistry (with laboratory practice and lectures), physiology and hygiene, geology, and mineralogy. The art classes can be made elective or special studies. The college has a fine gallery of art, anatomical cabinet, and museum of natural history. The last contains collections of fossils, minerals, rocks, etc., and the zoölogical museum is rich in ornithology. A considerable number of the Vassar graduates engage in teaching.

INSTRUCTION IN SEWING.

Sewing has been successfully undertaken in the public schools of

several cities, among them Baltimore, Newark, Boston, and Providence.

In the report of the school commissioners of Baltimore for 1879 it is stated that at the request of the president of the board some of the teachers commenced teaching sewing, knitting, embroidery, and other useful branches, one afternoon each week being devoted to this instruction of the female pupils. The experiment was satisfactory to both pupils and patrons, and a general wish for its continuance was expressed.

In Newark five primary industrial schools are established for poor and destitute children. The pupils in them spend a portion of their time in work, a portion in regular class-room duty, and another portion in receiving a dinner. The dinner and the materials for work are provided by a society of ladies, while the board pays the educational expenses, not exceeding $200 for each school. The superintendent says:

> Nothing in our schools gives me more pleasure than to witness the sewing exercise of the girls. Many receive here all the instruction in this most useful art they ever obtain.

The rules for the department of sewing in the public schools of Boston give a good view of the scope and requirements of the system employed there. They are as follows:

(1) Two hours a week, as appointed by the regulations of the school committee, shall be given to each scholar of the fourth, fifth, and sixth classes of the grammar schools, one hour at a time, for instruction in sewing. This time should not be shortened for other studies or examinations, or any other purposes, without the consent of the committee on sewing especially obtained.

(2) Each scholar shall be requested to bring work from home prepared, as far as possible. But in any case where it is not so provided, the sewing teacher will be expected to have work on hand, that there may be no excuse for an unoccupied hour, and that time may not be wasted in sending home for work.

(3) A sufficient supply of needles, thread, and thimbles shall be kept on hand by the sewing teacher to furnish to any child who is without them from carelessness or inability to supply them, or who has not the proper needle or thread for her work.

(4) The sewing teacher is requested to make all preparation and fitting of work out of school, that she may give the whole hour to the oversight of the work. Any fitting that requires time should be laid aside to be attended to out of the hour, and other work supplied in its place.

(5) Every effort should be made to vary the instruction, that every girl may learn thoroughly the varieties of work. If she has learned one kind of work the sewing teacher is requested to furnish her with some other variety, that she may be made efficient in all kinds of work. In this way, patchwork should be discouraged after a scholar has learned thoroughly what can be learned from it. Every effort should be made for promotion in work, from plain sewing through the darning of stockings to nice stitching and button-holes, from the simpler to the more difficult, in order to give an interest and desire for perfection in such work. It is a good plan to keep pieces of cloth for practice in making button-holes, stitching, or any other such special work, which can be given whenever there is want of work, or if other work has been completed in the course of the hour, or to carry out the idea of promotion.

(6) The sewing teacher may find assistance from any charitable society with which she is connected, which would willingly furnish garments prepared and fitted, to be returned to the society when completed. Or she can suggest to any scholar who has not provided material for her work, that she show to her mother the garment she has finished at school, and offer it to her for the price of the material. Many a mother would like to buy such a garment for its use or for a specimen of work, if it is well done.

(7) The regular teacher of the class is expected to take entire charge of the discipline of the class, as she is more thoroughly acquainted with her scholars; also to see that the work is distributed promptly, at the beginning of the hour, either by herself or through monitors, and to assist in keeping each scholar diligently occupied through the sewing hour. It is recommended that she should give credits or marks for efficiency and inefficiency in sewing, in the same manner and according to the methods pursued in other lessons in her class.

The history of sewing in the public schools of Boston begins as far

back as 1835. In that year an order was issued allowing the girls of the second and third classes of the public writing schools to be instructed in sewing by their regular teachers one hour a day. In 1854 this branch of instruction was included among those taught in the lowest class of the grammar schools. Lessons of not less than an hour in length were given twice a week. Materials for sewing, to an amount not exceeding twenty dollars annually, were furnished each school in which instruction in sewing was introduced. A reaction occurred the subsequent year, through the influence of the masters of the schools, and an order was passed permitting the discontinuance of the instruction when the interests of any school should be subserved thereby.

The introduction of instruction in advanced needlework was due to the philanthropy of a lady, who was allowed to provide materials and teachers for a class of older girls connected with the Winthrop school. This was in 1865 or 1866. The results of the experiment were satisfactory, and after some eight years the work was adopted by the school board. In 1875 it was decided by the city solicitor that it was not competent for the board to employ a special teacher of sewing. This difficulty was overcome by procuring an act of the legislature allowing sewing to be taught in the public schools of the State. Since that time the work has prospered. Exhibitions of sewing have contributed to awaken interest. Though poorly attended at first, they are now oftentimes crowded. They are so planned as not to interfere with the regular work of any school. Says a recent report:

> The sewing committee, and doubtless other members of the [school] board, have from time to time interesting proofs of the practical value of this industral training. Not infrequently young girls, fresh from school, find steady and remunerative employment, thanks to their skill with the needle. Others are now able to keep their own garments, and those of younger sisters and brothers, neat and tidy, when formerly rents and rags prevailed. And many graduates of our schools, in more favored positions, admit that they owe their skill in fine needlework entirely to the teaching received at school.

The cost of material supplied by the city in 1880–'81 was $208.23.

The following extracts are from a newspaper account of an exhibition of plain sewing done at one of the Boston schools:

> Several long tables were placed lengthwise in the room, and these were filled with garments and articles of household use, which had been made by the girls, whose ages ranged from eight to sixteen. There were shirts with plaited bosoms stitched by hand, every stitch set with the utmost precision; undergarments very prettily made and trimmed, in some cases entire sets trimmed with lace, which was also the work of the youthful seamstresses; dainty flannel skirts with embroidered edge, and seams done in a regular "feather stitch" or "herring bone," the old stitches that our grandmothers used so much and that are coming in vogue again with many other old fashions. One ambitious girl had made herself an entire suit of lace bunting; it was a pale shade of blue, and was made with short round skirt trimmed with a double row of side-plaiting, the upper one edged with lace, prettily-arranged draperies, lace trimmed and held in place with loops of satin ribbon, and a blouse waist with three plaits at the back and in the front. Every stitch was made by hand; there wasn't a touch of machine work about it, and the whole costume was stylish and jaunty. Dressing-sacks and wrappers were among the articles exhibited, and there were the cunningest of all little baby dresses and sacks. It is evident that the girls do a good deal of the home-work in those few hours each week. The specimens of lace-work were very handsome, a part of it being most exquisitely done, every stitch set with an evenness that was remarkable. During the afternoon half a dozen girls from the upper classes fitted dresses and drew patterns; they do this with ease and accuracy, and are very good fitters indeed. * * *
>
> The progress that has been made since the plan of having yearly exhibitions was carried out two years since is very marked. Not only has there been an improvement in the work, but individual taste has been cultivated as well. One sees it in the knots of ribbon that adorn the garments, in the very way in which they are folded, the quality of material, the dainty laundering, and the sheets of colored tissue paper set underneath the folds to show the work to better advantage. Not only are the

children taught to make, but to mend as well, and the manner in which some of these girls keep their garments in good repair is very gratifying. It is a good thing in more ways than one, this teaching; it makes the girls careful and tidy and gives them economical habits. Not a girl graduates from that school but may earn her own living by needlework if the necessity meet her, and she is not compelled to give time that she can ill-afford in learning to use the needle properly. If she has not to do this she becomes invaluable at home.

Specimens of work done by girls in the Winthrop School, Boston, are permanently on exhibition in the museum of the National Bureau of Education, and attract the favorable notice of visitors.

The teaching of sewing in private educational institutions has been generally limited to directing and assisting the young ladies for an hour or two each week while they do any necessary mending or other work with the needle. A few schools now have regular and thorough instruction in this department; for example, in the Kansas State Agricultural College "young ladies are taught in all the ordinary forms of sewing with needle and machine, and in cutting, fitting, and trimming dresses and other garments. They may furnish materials and work for their own advantage during the hour of practice under the direction of the superintendent." In Lasell Seminary opportunity is given to learn dress cutting and millinery, and many pupils gladly avail themselves of the offered instruction. The report of the industrial work of this institution, given in Appendix E, shows the results of this training, and plainly indicates its utility and success.

ELEMENTARY INSTRUCTION IN HOUSEHOLD ARTS.

Kitchen gardens.—Closely allied to the Kindergarten is the kitchen garden, a school which applies the principles of the Kindergarten to the instruction of young girls in various branches of household work. The end it has in view is the preparation of its pupils for practical work in the household, either as servants or as members of families. The instruction is given by means of toys illustrating domestic operations, and the children are directed in their play with these toys so that they learn many household duties and come to associate housework with pleasure and enjoyment. The course is divided into six lessons, to each of which a month's time is devoted. The first lesson embraces, among other subjects, fire-kindling, paper-folding, and waiting on the door; the second, the setting and clearing of the table and house-cleaning; the third, making beds and sweeping; the fourth, laundry-work; the fifth, the dinner-table and the names and uses of different kinds and pieces of meat; the sixth, the moulding of bread, biscuit, &c.

This system of instruction was originated by Miss Emily Huntington, of New York City, and the first "kitchen garden" opened there in 1877. Since that time the system has been introduced into schools in many prominent cities, and is welcomed by people of wealth and culture as a means of introducing order and intelligence into the homes of the poor, and of inspiring an early love for domestic work; and, as a prominent paper remarks, "It seems to be a step toward solving the old problem of how to obtain a supply of skillful, intelligent, and contented household servants."

The latest report received gives an account of eleven different schools or classes in progress, with 200 children under instruction. There were several classes or lecture courses in progress for the training of teachers. This development of the Fröbel methods of object-teaching seems to be peculiarly adapted to the practical character of our people and to the needs of the times.

INSTRUCTION IN DOMESTIC SCIENCE.

Instruction in domestic economy forms a considerable part of a young lady's education in several of the European nations, and is coming into prominent notice in this country. In Germany the instruction and the methods of imparting it conform to the social position of the parties instructed; but in England, as in this country, the instruction is given in schools established for the training of any who may wish to avail themselves of their advantages. The most prominent of the English schools is the National Training School for Cookery, at South Kensington; it was maintained by subscriptions, donations, and fees until the government gave it, in 1873, the use of a building and in 1874 an endowment.

The establishment of schools of cookery in this country is largely due to the efforts of a few efficient ladies who realized the imperative need of the general adoption of more economical and healthful methods of cookery. Successful schools have been opened in many leading cities. A historical sketch of the New York School of Cookery and an account of the work of Miss Maria Parloa are given in Appendix E.

In addition to the distinctive schools of cookery there are several institutions which provide instruction in this and in other equally important household arts. The schools in which young ladies are required to share in the domestic work for the sake of health, discipline, and the reduction of expenses are not included among them. They usually assert that it is not their intention to teach the industrial pursuits of the home. For example, the catalogue of Mount Holyoke Female Seminary, South Hadley, Mass., in which it is well known that there are labor requirements, says:

> It is no part of the design of this seminary to teach young ladies domestic work. This branch of education is exceedingly important, but a literary institution is not the place to gain it. Home is the proper place for the daughters of our country to be taught on this subject, and the mother the appropriate teacher.

If it be conceded that a majority of mothers have the opportunity, ability, and disposition to teach their daughters household arts, yet it must be allowed that there are many who have not the power to become teachers of such things. Some are ignorant of the subjects to be taught. Some are not strong enough to undertake the task. Others are too much engaged in undertakings which have no direct connection with the home. It seems no more than fair that mothers busied by a multitude of calls and duties, or deprived by sickness of the privilege of keeping their place in the family, or consciously deficient in skill themselves, should be able to find schools in which their daughters could be trained in those things which lie peculiarly within the province of the mother. A great end of primary schools is to aid and extend home instruction, and it is not a valid objection that lessons are learned in them which mothers might better teach. The mother is the appropriate religious teacher of children of tender years, yet the instruction of such children in Sunday school is not generally objected to by Christian people. Brief mention may be made of instances in which this principle of teaching what belongs especially to the mother is carried out in relation to home labors and duties.

In the Elizabeth Aull Seminary, Lexington, Mo., there is a school of home-work where "are practically taught all the mysteries of the kitchen and laundry, such as the making of pastry, pickles, sauces, cakes, ornamental icing, and the washing of flannels, ruffles, and laces."

The degree of mistress of home work is conferred upon graduates in this school.

The ladies in the Kansas State Agricultural College are given during their third year a course of lectures on the laws of life and health. The course is ten weeks in length, and brings up questions pertaining to personal health, such as food, air, exercise, clothing, and temperature of rooms. There is also a series of lectures on household economy, accompanied by practical illustration in the kitchen laboratory, continuing through a term and a half. These cover the general ground of economical provision for the household, marketing, cooking, preserving, order, neatness, and beauty in table service, comfort of family, and care of sick room. These are supplemented by the lectures upon household chemistry and dairying.

In the Pennsylvania State College female students substitute a course in domestic economy for the practical instruction on the farm and campus taken by the men. This course is intended to give a knowledge of the application of science to the work of the kitchen and laundry, a further acquaintance with drawing, and some familiarity with the principles and practice of house decoration. The studies included and the time devoted to each may be seen by reference to the statement respecting the college, found in appendix A.

At the Hampton (Va.) Normal and Agricultural Institute instruction in sewing and household industries is continued through the cou e, special attention being given in the middle year to plain cooking and sewing.

In Missouri University a course of lectures on domestic chemistry is given to students intending to graduate in the girls' course in arts. The instruction is given upon the general topics of air, water, food, and cosmetics. Under the head of air such subjects are considered as respiration, ventilation, heating of houses, clothing, and the germ theory of disease. All the properties of food, the methods of its preparation, and its nutritive and hygienic values are discussed. In this way the young ladies receive correct ideas of the subjects which pertain to the health, comfort, and happiness of the human family.

Extended accounts of what has been accomplished in the industrial training of women in Lasell Seminary, Auburndale, Mass., in the Iowa State Agricultural College, and in the Illinois Industrial University are to be found in Appendix E.

TRAINING SCHOOLS FOR NURSES.

The establishment of training schools for nurses is a wisely directed, philanthropic effort; and all who need the skilled hand and accurate judgment of an experienced nurse, or are interested in enterprises the purpose of which is the alleviation of suffering and the recovery of health, will allow that these schools furnish a considerable element in the promotion of the practical education of woman. They are preparing suitable women for the onerous and responsible duties of nursing in both hospital wards and private residences, and they are working with most commendable zeal and thoroughness. The statistics of these schools are presented in the table given herewith; and facts which indicate the general features of the schools, such as requirements of admission, nature and methods of instruction, success of pupils and graduates, etc., are set forth in the subsequent statements. Schools other than those which the statistics and statements here given represent are either organized or about to be organized in many other cities.

Statistics of training schools for nurses; from replies to inquiries by the United States Bureau of Education.

	Name.	Location.	Date of incorporation.	Date of organization.	Superintendent.	Number of instructors.	Present number of pupils.	Graduates in 1880.	Total number of pupils since organization.	Graduates since organization.	Number of years in full course of study.	Number of weeks in school lastic year.	Salary paid pupils.	Conditions of admission.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Connecticut Training School for Nurses (State Hospital).	New Haven, Conn.....	1873	1873	Gertrude Barrett...	4	24	8	*116	43	1½	50	$174 yearly, with board and washing.	Age, 22–40; good health and character, and common school education.
2	Illinois Training School for Nurses.	Chicago, Ill.....	1880	.....	M. E. Brown.....	....	....	....	.....	.....	2	....	$8 a month for first year; $12 a month for second.	Age, 25–35; sound health and good education.
3	Boston City Hospital Training School for Nurses.*	Boston, Mass.....	.....	1878	Alice C. Davis.....	a16	42	17	79	19	2	52	$10 a month for first year; $14 a month for second; $20 to $30 head nurses (graduates).	Preference given to applicants between ages of 25 and 35; if otherwise good, applicants between 21 and 25 may be admitted.
4	Boston Training School for Nurses (Massachusetts General Hospital).	Boston, Mass.....	1875	1873	Jane E. Sangster....	....	42	16	247	73	2	50	$10 a month for first year; $14 a month for second.	Preference given to applicants between 25 and 35 years of age.
5	Training School for Nurses (New England Hospital).	Boston, Mass. (Codman avenue, Roxbury district).	b1863	1872	H. F. Kimball, chairman of nurse committee.	c1	16	6	83	40	1⅓	50	$1 a week for first 6 months; $2 a week for second 6 months; and $3 a week for the last 4 months.	Age, 21–31; satisfactory references of character and capacity and a month's probation.
	Missouri School of Midwifery.	St. Louis, Mo.....	1875	1875	Wm. C. Richardson, M. D., president.	3	16	21	*180	*173	1	16	None.....	A common school education.
6	Brooklyn Training School for Nurses.	Brooklyn, N. Y.....	.....	1880	M. E. Snyder.....	1	10	0	10	0	2	52	$9 a month for first year; $15 a month for second year.	Age, 21–35; sound health, good education and character.
8	New York State School for Training Nurses.*	Brooklyn, N. Y. (46 Concord street).	1873	1873	A. H. Wolhaupter..	8	7	5	66	47	1	52	Boarded and lodged during the entire course of instruction.	Age, 21–40; satisfactory references as to moral character and general health, ability to read and write, and an agreement to remain one year.

* From Report of the Commissioner of Education for 1879.

a These are 1 matron and 15 head nurses.

b Date of incorporation of hospital.

Statistics for training schools—Continued.

	Name.	Location.	Date of incorporation.	Date of organization.	Superintendent.	Number of instructors.	Present number of pupils.	Graduates in 1880.	Total number of pupils since organization.	Graduates since organization.	Number of years in full course of study.	Number of weeks in scholastic year.	Salary paid pupils.	Conditions of admission.
9	Charity Hospital Training School.*	New York, N. Y. (Blackwell's Island).	.....	1875	Harriet L. Clute....	(*d*)	40	28	120	57	2	52	$10 a month for first year; $15 a month for second.	Age, 20–35; good health and character, and good English education.
10	Training School for Nurses (Bellevue Hospital).	New York, N. Y. (426 East 26th street).	1872	1873	E. P. Perkins	6	63	29	209	148	2	50	$9 a month for first year; $15 a month for second.	Age, 25–35; satisfactory references from clergyman and physician, and a knowledge of simple arithmetic, reading, penmanship, and English dictation.
11	Training School of New York Hospital.*	New York, N. Y. (West 15th street).	.....	1877	Eliza Watson Brown.	4	26	14	52	14	1⅓	52	$10, $13, and $16 a month for the first, second, and third 6 months respectively; graduates, $25.	Age, 25–35; sound health, perfect senses, good moral character, and good common school education.
12	Training School for Nurses (House and Hospital of the Good Shepherd).	Syracuse, N. Y.....	1873	1872	Mary D. Burnham..	8	10	....	.....	.....	...	....	$10 a month and board and lodging.	
13	Nurse Training School of the Woman's Hospital.*	Philadelphia, Pa. (North College avenue and 23d street).	*b*1861	1863	Anna E. Bromall, M. D.	*c*1	17	10	117	*e*46	2	52	$5 a month for first 6 months; $10 a month for second 6 months; $16 a month for second year.	Age, 21–45; intelligence, good character and habits.
14	Philadelphia Lying-in Charity and Nurse School.	Philadelphia, Pa.....	.....	1836	.....	....	..	....	.....	.....	...	....	....	
15	Washington Training School for Nurses.	Washington, D. C....	1877	1878	J. M. Toner, M. D., president.	7	10	3	24	3	2	50	None.....	Must not be under 21; must furnish certificates of health, good moral character, and possess a common school education.

* From Report of the Commissioner of Education for 1879.
a These are 1 matron and 15 head nurses.
b Date of incorporation of hospital.
c Also lecturers.
d Instruction given by hospital physicians.
e Since 1873.

Admission.—It is recognized in all schools for the training of nurses that the duties of a nurse are such that only those who have peculiar aptness for the work and who possess mental, moral, and physical strength, should be encouraged to undertake it. In order to make an estimate of an applicant's fitness, it is the custom of several schools to send her a list of questions the answers to which will enable the authorities to estimate her suitability for the vocation of nurse. The list sent out by the New York Hospital Training School, which fairly represents the usual questions, is as follows:

(1) Candidate's name in full, and address; (2) condition in life, single or a widow; (3) present occupation or employment; (4) place and date of birth; (5) height; (6) weight; (7) where educated; (8) are you strong and healthy, and have you always been so? (9) Are your sight and hearing perfect? (10) Have you any tendency to pulmonary complaint? (11) Have you any physical defects? (12) If a widow, have you children? How many? How old? How are they provided for? (13) Where (if any) was your last situation? How long were you in it? (14) Names in full and addresses of two persons to be referred to. State how long each has known you. If previously employed, one of these must be the last employer. (15) Have you read and do you clearly understand the regulations?

In the Connecticut Training School, the secretary corresponds with the applicants, and thereby becomes sufficiently acquainted with their character and capacities to discern any special improbability that they would pass successfully through the course of training. If this is the case, the applicant is advised to seek employment elsewhere.

The suitable age of applicants is generally placed at from twenty-one to thirty-five years. The reason given is that those younger have not ordinarily sufficient mental and physical development, and those older do not readily acquire new habits. The necessity of good character in a nurse is obvious, and the need of sound health is equally so, for none are ignorant of the sacred trusts and arduous duties which devolve upon her. The amount of education required of applicants is not very great, as natural ability and willingness to learn are the chief requisites. Often pupils are admitted without examination on the statement that they have acquired a common school education; but in at least one school —the one connected with Bellevue Hospital, New York—an examination is required in reading, penmanship, arithmetic, and English dictation.

The various requirements for admission and limited accommodations preclude the reception of the majority of applicants in many instances.

The New York State School makes up a class each year of only six from the large number of applicants. Of thirty-three who applied at Bellevue in December, 1879, only three were received. At the New England Hospital, in 1878, eighteen of forty applicants were admitted to probation. Of the remaining twenty-two, nine withdrew their applications, eight were not of proper age, and five were for various reasons considered unsuitable.

Probation.—The pupils of the nurse-training schools are usually admitted to a probation of one month, during which they receive no compensation for their services beyond board and lodging. A large portion of those thus admitted fail to meet the demands made upon them during this time. In one school, sixteen out of one hundred and five left during the probationary month. Of the eighteen mentioned above as admitted to probation in the New England Hospital, only nine were approved. Of the other nine, one left on account of death in the family, six were not thought strong enough, one was dismissed for disobedience, and one because unreliable. It could not be otherwise than that the first month's experience of a nurse should be full of difficulties

and discouragements. The secretary of the Connecticut Training School makes a clear presentation of this point in the following well-advised remarks:

> A severe test it (the month of probation) is to most of the young women who come to us from quiet homes where they have led for years a sedentary life. The active work required in the wards—bending over the beds of the sick, bearing patiently the caprices and exactions of invalids, witnessing surgical operations and other painful sights, dressing wounds and sores—presents hospital life under a different aspect from the one drawn by their imagination; and some, for want of strength, patience, or perseverance, fail to carry on the work on which they so hopefully entered. Others come to the school with a real self-consecration, and, although they may be almost discouraged by the recognition of all that is expected of them, yet if they faithfully discharge their duties as they meet them one by one and seem desirious to embrace every opportunity for improvement, they are encouraged to persevere, and soon acquire a skillfulness which enables them to do their work acceptably and with comparative ease to themselves.

Those fulfilling the conditions and expectations of the probationary month are usually required to enter into a written agreement to remain in the school, subject to its authority during the time allotted to a complete course, and sometimes to remain at the call of the school superintendent for a specified period after graduation. Without such an agreement, pupils would be drawn away before completing the course by tempting offers from other sources.

Maintenance.—Pupil nurses are maintained, with one or two exceptions, at the expense of the school, or the hospital to which it belongs, during the time of their training. The sums paid in addition to board and lodging are given in the table. These sums are not looked upon as a remuneration for services performed, as the instruction and experience are considered a sufficient compensation. But it seems desirable that the pupil should not be dependent on any one outside of the hospital for money to meet her expenses for at least dress and text-books, and therefore an allowance is made for them. The dress is often required to conform to rules relative to material, to plainness, and to other things which make it suited to the sick-room. Thus one of the regulations of the nurse training school at Philadelphia is:

> Nurses, while on duty, shall wear cotton dresses without crinoline and without trains, and soft shoes without heels. * * * White aprons must be worn. The utmost simplicity is enjoined both in outer and under clothing, as no ruffled, tucked, or flounced skirts nor trimmed garments are allowed to be sent to the hospital laundry.

In another school—

> They are required after the month of probation to wear the dress prescribed by the society, a gray woolen dress in winter and seersucker in summer, *simply made*, white apron and cap, and linen collars and cuffs.

The text-books are not numerous, being usually limited to a few works upon nursing, such as Domville's Manual for Hospital Nurses, Dr. Frankel's Manual, the Bellevue Hospital Manual, the Connecticut Training School Handbook, Florence Nightingale's Notes on Nursing, Mrs. Lee's Handbook, Miss Veitch's Handbook, and Smith's Notes.

The information in the possession of the office does not render it possible to state positively what provisions are made for the board and lodging of pupils in all cases, but it may be stated, as a general rule, that they have quarters in or connected with the hospital building, and removed as far as possible from the sick wards. It is most desirable that they should have, not a bare living place in a corner of the hospital, but a comfortable and attractive home, furnishing surroundings that rest, revive, and animate those that are weary and discouraged from excessive toil and care, and that give opportunities for undisturbed

sleep in the daytime to night nurses, and entire immunity to all from suggestions of the hospital. The Nurses' Home of the Bellevue Hospital provides for all these wants, and it has been said that the noticeable exemption from illness which the nurses of that institution have enjoyed is largely owing to their cheerful and healthy surroundings.

The maintenance of pupil nurses suggests an inquiry into the support of the schools or hospitals to which they are attached. Two schools make no report or statements that bear upon financial questions; two, which are connected with public hospitals, are supported in the main by city appropriations. The income for 1879 of the Bellevue Hospital Training School for Nurses was: services of nurses, $13,142; annual dues of members, $2,920; donations, $3,230.

The Connecticut Training School for Nurses received, in 1877, $1,003.55 for the services of nurses, while its entire expenses were $1,922.12. It has an endowment of $12,000.

The school at the Woman's Hospital of Philadelphia, in 1879, received enough for services of nurses to pay the expenses incurred by the hospital for its support.

The New England Hospital receives its income mainly from payments for yearly free beds, receipts for board, treatment, and medicine, income of funds, and subscriptions and donations.

The Boston Training School is supported by receipts for nurse services, subscriptions, and donations, and income of funds.

The New York State School is a part of the Brooklyn Maternity (hospital), which derives its income from contributions and collections, city appropriations, pay of patients, etc.

The Missouri School of Midwifery has fees of $75 for the entire course, and $10 extra if the pupil be admitted to the dissecting rooms.

Instruction.—The instruction afforded in nurse training schools seems to divide itself naturally into practical, or that received at the bedside of patients; theoretic, or that obtained from text-books and lectures; and auxiliary, or that which is useful in nurse-training, but not specifically a part of it.

Practical nursing must be learned at the bedside, and the beds of a hospital offer the best opportunities. There the nurse may observe the treatment of persons suffering from the various medical and surgical diseases, or who have undergone surgical operations, and thus she acquires an extensive and valuable experience in a short time. Sometimes there may be only a special class of patients treated in the hospital where the pupils of the nurse schools do their work, as is the case in the Brooklyn Maternity, but within any such class there is a wide variety of diseases and dangers. Usually there are several departments requiring nursing adapted to the cases included in each, in which pupil nurses serve in turn.

In the Connecticut Training School for Nurses "each has a special place assigned to her, and remains several weeks in charge of that department. In the course of the year she acquires experience in medical, surgical, fever, and confinement cases."

In the Boston Training School for Nurses the time is divided between medical and surgical cases, and between day and night duty, and each nurse has two months in the lying-in hospital.

At Bellevue Hospital, all the female wards, two male wards, the Sturges Pavi ion for the treatment of acute surgical cases, and the lying-in hospital, attached to Bellevue, are nursed by pupils of the school.

Another principal advantage in hospitals is the frequent presence of skillful physicians to give counsel and directions, and furnish instruc-

tion at a time when it will make a lasting impression on the pupil's mind. Then the advice and assistance of experienced nurses, especially on critical occasions, prepares the nurse for similar emergencies in the future, while the constant oversight of both head nurses and physicians stimulates the pupil to form habits of accuracy, fidelity, and attentiveness to patients. Although the practical drill obtained at the bedside under the supervision of experienced persons is of principal value, yet systematic instruction from carefully written manuals of nursing, and by lectures and talks on subjects pertaining to nursing, is not neglected. The course of instruction is very similar in the majority of the schools, and that of the Connecticut Training School for Nurses may be taken as a representative. The instruction includes (1) the dressing of blisters, burns, sores, and wounds; the application of fomentations, poultices, and minor dressings; (2) the application of leeches; (3) the administration of enemas; (4) the use of the catheter; (5) the keeping of temperature records; (6) the best method of applying friction to the body and extremities; (7) the management of helpless patients; removing, changing, giving baths in bed, preventing and dressing bed sores, and managing positions; (8) bandaging, making bandages and rollers; (9) making patients' beds and removing sheets while the patient is in bed; (10) the keeping of all utensils, sponges, bed, tables, etc., perfectly clean.

Other subjects of instruction mentioned in courses of training elsewhere are warming, ventilation, and care of sick rooms; the making of accurate observations and reports to the physician on the state of the secretions, expectoration, pulse, skin, appetite, temperature of the body, intelligence, as stupor or delirium, breathing, sleep, condition of wounds, eruptions, formation of matter, effects of diet or medicine; management of convalescents; attention during confinement and care of new-born infants; management of trusses and other appliances; the giving of baths; the stopping of hemorrhages; disinfectants. Some of the schools specify that examinations in the studies pursued are held either at appointed intervals or at the option of the examining officers. The annual report of one institution says that there have been 146 class recitations to the lady superintendents and five formal examinations conducted by members of the hospital staff. Another, "Our superintendent teaches the nurses from the best manuals we can procure, and examines them on the lesson. There are quarterly examinations by the lecturers and by the medical men among the directors."

The theoretic instruction in several of the schools is received only by lectures on the fundamental subjects of training. The Washington Training School announced for 1880–'81 six lectures upon each of the following subjects, viz: Anatomy, physiology, surgical nursing, medical (hospital) nursing, obstetrical nursing, medicines and dietetics, and nursing of children. The Boston City Hospital had provided 46 lectures for the training school in 1879–'80, as follows: On nursing of insane patients, circulation of the blood, care of surgical instruments and appliances, one lecture each; on poisons, common sense in the sick room, nursing and care of skin diseases, nursing and dressing of fractures, two lectures each; on eruptive fever, administering of medicine, nursing in confinement, physiology and food, care of nervous patients, three lectures each; on care of the eyes, four lectures; on anatomy and surgical dressings and appliances, five lectures each; on general diseases and emergencies, six lectures.

The education of pupil nurses in branches collateral to their profession is not extensively attempted in the training schools. Usually they are

taught how to prepare delicacies for the sick, attractive articles of diet, and the drinks and stimulants in common use. On the subject of medical instruction the secretary of the Connecticut Training School for Nurses remarks:

> Whilst far from wishing our nurses to be so learned as to think they know as much as the physicians, we are desirous to have them understand the structure of the human body and all its functions; for this purpose they study from text books on physiology, anatomy, and midwifery, reciting to, and receiving valuable instruction from, the head nurse, who also conducts quarterly examinations in these studies in the presence of the ladies of the executive committee.

Results.—The success of these training schools may be seen in the excellent work done by the pupil nurses in both hospitals and private houses, in the thorough preparation they give for a life work in a noble calling, and in the appreciation in which their services are held by the medical profession and others after their graduation. A report speaks thus of the benefits which the establishment of the nurse training school brought to the inmates of the Charity Hospital of New York:

> The change wrought in the hospital was sudden and radical. The nurses themselves were of a better class than it was thought possible to secure, many of them being ladies of culture and refinement. Abuses which had existed since the foundation of the hospital were at once swept away. The care and sympathy received by the patients promoted their recovery, while the presence among them of the pupils of the school so improved the moral tone of the institution that the calls for punishment were no longer necessary and were removed. The death rate of the hospital has steadily diminished since the introduction of the training school. * * Other causes have contributed to diminish the mortality, but none so much as the increased efficiency in nursing, due to the careful training of intelligent nurses.

Quotations from two reports will indicate the excellence of the work done by the pupils in private families and the constant demand from that direction.

A recent report of the Connecticut Training School for Nurses says:

> We have been able to respond this year to thirty-six applications for the services of trained nurses, and in each case the one sent has returned to us with a certificate from the patient or the attending physician which testified to her efficiency and the value of the school as an educator.

The Bellevue Training School says:

> The demand for nurses in private families has increased far beyond the ability of the school to supply. One hundred and forty persons have been attended by nurses from the school, and twenty-nine graduated nurses have been fully employed during the year in New York and the vicinity. The managers have been much gratified by the satisfactory reports which the nurses have brought back from physicians and employers.

The following paper is sent with pupils that go out from this school for the purpose of private nursing.

New York Training School for Nurses, 426 *East Twenty-sixth street.*

——— —, 18—.

This day the nurse ——— ——— has been sent on the recommendation of ——— ——— to nurse in case of ——— ———.

———— ————,
Superintendent.

REGULATIONS.

The charge for the services of a nurse is $3 per day, or, if employed one week or more, $16 per week. Traveling expenses and washing to be paid by the family employing the nurse.

All applications must be made personally, or in writing, to the superintendent.

When the nurse's services are no longer required, this sheet of paper is to be returned, sealed up, with a candid statement, on the fly-leaf, of her conduct and effi-

ciency, either from one of the family or the medical attendant, together with information of the amount to be paid, and whether it is inclosed or will be paid at the office of the society.

The nurse is to be allowed reasonable time for rest in every twenty-four hours; and when her services are needed for several consecutive nights, at least six hours in the day out of the sick room must be given her.

Except in cases of extreme illness the nurse must be allowed opportunity to attend church once every Sunday.

When on duty the nurse is always to wear the dress prescribed for her by the regulations of the society.

Patients and their friends are invited to contribute to the general funds of the society, and thus assist in enabling it to afford the advantages of gratuitous nursing to the poor, which is one of the objects the association hopes to accomplish.

Where it is possible, a few days' notice of the nurse's return to the home should be sent to the superintendent.

Copy of paper to be rsturned by employers.

———, 18—.

The services of the nurse ——— ——— being no longer required, she is this day set at liberty to return home, and the sum of $———, being the remuneration for her attendance, is ———

(Signed) ——— ———.

Remarks as to conduct, efficiency, etc.

The post graduate success of educated nurses, which is the evidence of their training, is manifest from the continued call for their services in preference to those of any others, and receives further proof from letters written by those who have observed their work; and the same may be said by the citizens of any city possessing a nurse training school that Felix Adler said of the one at Bellevue:

It is one of the beneficent institutions of our city, in which every New Yorker may take a legitimate pride, and of which there can be no doubt that it is destined to become a source of inestimable blessing to the community.

EDUCATION IN MISCELLANEOUS INDUSTRIES.

Telegraphy.—Women may receive instruction in telegraphy in at least thirty-three business colleges and commercial departments; in five or six colleges not having such a department; in a few institutions for the superior instruction of women; and in several special schools, among which the Cooper Union School of Telegraphy is pre-eminent. The following is its report for 1882:

This school admitted 60 pupils this year. About 160 applied at the regular examination and passed, but they could not be admitted to the class for want of room. The Western Union Telegraph Company has so far interested itself in this school as to pay a teacher, who trains the pupils in the thorough methods of that company. They can thus draw competent operators for their offices from this school, and have provided a large proportion of the graduates of this school in times past with employment on their lines, although they are under no special obligation to provide a place for any. At present the supply of operators is less than the demand; and the extension of lines going on rapidly over this vast country will always make a steady demand for the employment of women in telegraphy. Their fidelity, intelligence, and patience will always give them the larger share of this kind of work, from which the young men are drawn away by a more active and ambitious life. The number of pupils remaining at the end of six months' instruction was 55, and the number receiving certificates was 28.

Stenography.—There are a few institutions for higher instruction furnishing training in some form of short-hand writing, among them Oskaloosa (Iowa) College and Battle Creek (Mich.) College. The usual places of instruction are private classes, of which the office has no information,

and business colleges, some twenty of which offer this branch of instruction to ladies as well as gentlemen.

Practical design for manufactures.—A school of practical design is connected with the Massachusetts Institute of Technology. The art of making designs for fabrics is taught by means of practical work done under the personal direction of a skilled designer. The course embraces technical manipulations, copying and variation of designs, original designs or composition of patterns, and the making of working drawings. A weaving department is associated with the school, and observation of manufacturing on a larger scale is made during occasional visits of inspection. The expense to pupils is about $5 a year for instruments and material. Applicants are required to show some acquaintance with free-hand drawing and the use of drawing instruments.

Printing.—The employment of women in printing offices is increasing, and, in order to encourage them in fitting themselves for remunerative positions in these offices, the Kansas Agricultural College remits the fees of women taking the courses of instruction in printing. Two courses are pursued in this art. In one the student is given a general view of the rise and progress of printing, of type-founding, stereotyping, electrotyping, and lithography. He (or she) is taught the implements or tools employed in typography and how to use them, composition, imposition, principles and practice in plain and ornamental job-work, presses and their working, technical terms, and general duties of a first-class workman. The second course, the lessons of which alternate with those in the first, embraces instruction in spelling, capitalization, punctuation, proof-reading, and correcting, preparation of essays and criticisms on the same, and such other miscellaneous work as will make the student accurate and expert in language.

Dairying.—During the spring term daily instruction and practice in the different branches of dairying is given the ladies of the second year in the Kansas State Agricultural College by the professor of agriculture.

Horticulture.—It has seemed proper to several institutions to provide instruction in horticulture with special reference in some cases to the training of women. The Agricultural College of Missouri justifies the existence in it of an extended horticultural course, on the ground that it is but a fair recompense to the women of the State, who have succeeded in creating a taste for the cultivation of fruits and flowers and for ornamental grounds, that their daughters, as well as their sons, be provided with a school where they may perfect themselves in these pursuits. The course extends over four semesters, and includes propagation of plants, pruning and training, gardens and gardening, floriculture and transplanting, pomology and forestry, ornamental trees and shrubs.

Facilities for the study of horticulture are provided in Cornell University, Ithaca, New York, the instruction being given throughout the third year in the agricultural course. During the first term, attention is given to fruit culture and forestry; during the second, to vegetable culture; the third, to floriculture, including landscape gardening. The general subject (of floriculture) is divided into the following topics: window-gardening, general management of house plants, hanging baskets, climbing vines, flowering bulbs, ferneries, wardian cases, etc.; outdoor flower-gardening, lawns, ornamental shrubs and trees, commercial flower-gardening.

Similar horticultural courses exist in many of the other institutions endowed with the national land grant, and one or two colleges have

also introduced instruction in horticulture, but the office has no information from which it can judge of the success of their work.

SECTION 4.

CONCLUSION.

The results expected of industrial education, and foreshadowed already by past achievements, are found in the improvement of our manufactures, the elevation of the producing classes, the removal of obstacles to learning a trade, the diminution of crime, the popularization of education, and the dissemination of peculiarly American ideas.

The manufacturer is aided by industrial education through the improvement of his products. His success depends on the demand for his goods at reasonable prices. This demand is regulated by the needs of customers. They ask for durability of material, attractiveness of design, and excellence of workmanship in whatever they purchase for permanent use. Manufactures improve as they become possessed of these and similar qualities, which can be economically secured only by the application of technical knowledge. Durability arises from excellence of raw material and is retained by the selection of the right processes by which to convert it into the state in which it finally appears. The quality of raw materials is not unfrequently to be determined by chemical tests, and many of the processes of its manufacture are regulated by chemical principles. The science which guides in the determination of these processes must be the one which will lead to their improvement and perfection. Hence courses in chemistry are established in our principal polytechnic schools as well as in colleges of agriculture (to which science chemistry makes liberal contribution), and in schools of mining and metallurgy. For a similar purpose engineers are taught to determine the strength of materials used in building railroads and bridges, houses and machines. Investigations in the domain of physics and chemistry have frequently taught the skillful application of new and serviceable agents to the production of labor. Efforts to render products more attractive in design are being made through schools and school systems by the introduction of drawing. From this art architects and designers acquire the power to represent the forms and patterns which, according to their judgment, will be most acceptable. Whether utility or elegance is the end to be obtained, it matters not. Either calls for the draughtsman's best production. In fact, the presentation of proofs that increased attractiveness in manufactured goods comes from excellence in drawing would be needless.

The end to which drawing contributes most frequently is accuracy of mechanical construction. The pencil precedes the hand and the machine. It leaves little for them to do but to execute with exactness the most minute details. In order to do this the workman must be able to interpret the drawings and reproduce the indicated forms. He must understand the language in which they are described, and acquire by education and experience the ability to obey it. Men of this class have laid out our railways, opened our mines, started and improved our manufactories, and built our houses. They have aided in increasing our industries 35 per cent. in the last decade and in compelling an English confession that "the United States will probably pass us in the ensuing decade" in the value of her industries.

The elevation of the working classes is an inevitable result of educating them in industries. The direct effect upon the intellect is great and beneficial. The immediate moral influence is of the best. A manly

feeling is awakened and kept alive by the consciousness of power and skill to do. An incentive to enterprise and frugality is set forth. It has been laid down as a rule by Prof. Edward Atkinson that—

> Other things being equal, high wages coupled with low cost are the necessary result of the most intelligent application of machinery to the arts, provided the education of the operative keeps pace with the improvement of the machinery.

In this way wages are increased and the cost of living diminished. Things consumed are not made expensive through waste caused by ignorance. It is a fact, recognized by manufacturers, that more highly skilled and better paid laborers produce goods at lower cost. Unde these circumstances a laboring man can reasonably entertain hope that he may possess, by careful industry and economy, the things whic his better nature most craves, a home, the implements of his trade, a few books, some dollars in the bank. The time seems to have come when a poor man's family need not be his misery. Property may accumulate; wealth possibly be attained. The moral value of such possibilities is incalculable; and therein lies the elevating power of industry well paid and well performed, and of education toward some of its branches. Few will deny that the training for a legitimate calling, and the pursuit of it with earnest application and perseverance, though done for the express purpose of gaining a competency, contributes to morality and virtue, and lays no stumbling blocks in the way of intelligence and education. There are the soundest reasons for believing that the instrumentalities in operation for the promotion of industrial education are silently yet powerfully lifting the laborer to a higher position. The immediate future will reveal this truth clearly. The well known statistician Col. Carroll D. Wright cautiously and significantly says:

> There is a slow but constant decrease in the number of laborers who seem to be doomed to remain at the bottom; a decrease in the number who are able to employ nothing but muscle. If this be true, and all my own observations indicate it, the status of what is now unskilled labor will be vastly improved during the next generation.

A recent writer on Holland represents the peasants around Grönin-gen as wandering about the city after their produce is sold and their purchases made "casting compassionate glances at all that population of shop-keepers, clerks, professors, officials, proprietors, who, in other countries, are envied by those who till the ground, but here are regarded by them in the light of poor people." It is not impossible that the industrial classes of our country may be brought by suitable education to occupy, and realize that they do occupy, a place to be envied by many of those engaged in mercantile and professional pursuits. George MacDonald is credited with saying:

> I would gladly see a boy of mine choose rather to be a blacksmith, or a watchmaker, or a book-binder, than a clerk. Production, making, is a higher thing in the scale of reality than mere transmission, such as buying and selling. It is, besides, easier to do honest work than to buy and sell honestly.

The entrance to industrial occupations has been beset by difficulties and discouragements. The apprenticeship system first degenerated and then died. Scarcely any one but a father will direct a novice in mechanical labor, and he rarely has ability and opportunity. Now the defect is being remedied. Boys are going from our manual training schools and departments of mechanical engineering to honorable and responsible positions in mills, foundries, and factories. Three or four years of study and practice have given them a broad intelligence and more training than the customary seven years' of apprenticeship ordinarily gave to boys of the olden time. By these schools, whose

work has been reviewed in the preceding pages, the question of how to obtain preparation for industrial employment has been answered.

Industrial education dignifies labor as well as opens doors to its skillful and remunerative performance. If labor has a noble end and purpose, if it employs intellect, if it abundantly rewards its servants, then it is worthy to be crowned.

The perfection of our manufactures, the facilitating of commerce, the unearthing of mineral wealth, the economizing of the fertility of farms, the dissemination of practical knowledge, these are ends which are being served by the graduates of our industrial institutions. These ends do not lack nobility. These forms of labor require the exercise of high intellectual powers. The attainments are of no mean order which enable a man to perform the great feats of engineering for which our country is becoming known or which are required of superintendents of extensive factories. Even the doing of a single thing understandingly and well brings the doer respect from himself and his neighbor and dignifies his calling. "It is the privilege of any human work which is well done," says Emerson, "to invest the doer with a certain haughtiness. He can well afford not to conciliate whose faithful work will answer for him."

The diminution of crime is to be expected from the diffusion of industrial education. The percentage of criminals who have received even the elements of an education is small. An authority on the subject has said that "one-third of all criminals are totally uneducated, and that four-fifths are practically uneducated." Yet when the relative number of convicts who are illiterate is compared with the number of those who have not learned a trade it is found to be much smaller. It is stated by Dr. Wines that in Baden only 4 per cent. of the prisoners are unable to read when received, and that they are for the most part fond of reading, but that 50 per cent. have not learned a trade; in Bavaria 12 per cent. are illiterate, 29 per cent. ignorant of a trade. Mr. Charles F. Thwing a few years since claimed that 60 per cent. of the inmates of the Michigan State prison had no trade, while less than 25 per cent. could not read, write, and cipher; that in the prison of Minnesota 37 of 235 prisoners could not read and write, 130 never learned any business; and that in the Iowa penitentiary the ratio of illiterate convicts to those unskilled in a trade was about 1 to 6.

Whatever may be the reliability of these figures it cannot be denied that the lack of technical training is a prolific cause of crime. This lack is being supplied to some extent by recently established schools, which both afford opportunities for such training and draw public attention to the existing need of it.

The introduction of industrial features into educational institutions has a tendency to relieve education of the accusation that it is unpractical. There are those that ask of our schools more than they are intended to furnish. Their voice in years past called into being manual-labor and half-time schools. Since the failure of these means to realize the expectations of their advocates, believers in education for industrial laborers have been uncertain what course to adopt in carrying out their views. Now it may be said with safety that the mass of our citizens are convinced that the educational systems and institutions of the country are above reproach, and will be modified by the introduction of new features as they are needed. A minority are disposed to be critical and assert that education is unwisely conducted, and that governmental aid might be applied more reasonably to the establishment of public farms and work-shops for training purposes than to public schools.

That which has seemed better to them than existing methods is taking place. It may be anticipated that as the day approaches when training in mechanic arts and agriculture shall be as possible as in literature and science the sounds of complaint will be fewer and prejudice less frequently will dull the weapons by which the forces of ignorance are being destroyed.

Finally, the protection of American institutions demands the industrial education of our youth, that they may carry our ideas of obedience to law and our republican principles into the midst of the multitude of foreigners that crowd our factories and our mines and perform much of our labor.

Ours is a peculiar nation. In it the principles of morality prevailing in civilized countries are upheld with warmth and reason. Our political principles are distinctive and characteristic. Daniel Webster enumerated them in one of his great speeches. They are the establishment of popular governments on the basis of representation; the recognition of the will of the majority, fairly expressed, as having the force of law; the supremacy of law as the rule of government for all, and the existence of written constitutions founded on the authority of the people. He asserted his belief that the influence of town meetings in which American principles were recognized and followed made those who went from them to dig gold in California "more fit to make a republican government than any body of men in Germany or Italy." If there be added to the lessons of our political gatherings and elections education in the essentials of government, instruction in the sciences contributing to human prosperity, familiarity with the languages of civilization, sound rules for the conduct of life, and training for an ennobling and enriching occupation, then American youth will be prepared oftener to fill leading places in industries, will win respect for their skill, learning, and wisdom, and, being respected and trusted, will be enabled to enshrine American liberty more securely in the hearts of laboring men. So our land shall be the home of a safe and permanent nation, "where an industrious population advances like a victorious army, where the poor find work, the laborer becomes a proprietor, the proprietor grows rich, and all have the hope of a prosperous future;" and the ends of our industrial education will be accomplished.

APPENDIXES.

APPENDIX A.

STATEMENTS RESPECTING THE INDIVIDUAL INSTITUTIONS ENDOWED WITH THE NATIONAL LAND GRANT.

ALABAMA.

STATE AGRICULTURAL AND MECHANICAL COLLEGE.

[Report of President I. T. TICHENOR, D. D.]

In compliance with your request, I have the honor to submit the following report of the Agricultural and Mechanical College of Alabama.

It was designed that this college should conform, as nearly as its means would permit, to the demands of the law of Congress: that without excluding other scientific and classical studies and including military tactics, its leading object should be to teach those branches of learning which relate to agriculture and the mechanic arts, with a view to furnishing a liberal and practical education to the industrial classes.

If in any respect we have come short of this design, it has been because we lacked the means for its full accomplishment.

Our endowment is derived entirely from the sale of lands donated by act of Congress, and consists of Alabama State bonds amounting to $253,500, bearing 8 per cent. interest, payable semi-annually. The only other source of income is an incidental fee of $15 per annum charged each student. Our annual income from these sources averages about $22,500.

The grounds and buildings were donated to the college by the trustees of the East Alabama College. The cost of the main building, which was erected in 1858, was about $65,000.

A farm, donated by citizens of Auburn, to which additions have been made by purchase, comprises about 100 acres, with farm-house, stables, &c.

The annual expenses of the college are equal to its income of $22,500. The salaries of professors and instructors amount to $17,600 per annum.

The faculty of the college (1880) consists of (1) a president, who is professor of moral philosophy, (2) a professor of engineering, who is also commandant, (3) a professor of ancient languages, (4) a professor of chemistry, (5) a professor of mathematics, (6) a professor of agriculture, (7) a professor of natural history, (8) three instructors, two of whom are engaged as teachers in the preparatory departments.

The number of students for the year ending June, 1879, was 279. The number in classes last year was: First class, 13; second class, 31; third class, 51; fourth class, 78; preparatory department, 104; post-graduates, 2.

The number of graduates of the college since its organization in 1872 is 42; of these there have been graduates in the literary course, 14; scientific course, 7; engineering course, 14; agricultural course, 7.

The inability of many of our students to remain at college long enough to accomplish the entire course has greatly diminished the number of graduates. Seven hundred and fifty young men have received instruction here since the organization of the college; many of these who did not graduate are engaged in useful and honorable vocations.

Of those who have terminated their connection with the institution whose employment we have been able to ascertain, there are engaged in agriculture, 222; mechanical pursuits, 40; teaching, 30; the professions, 40; and commerce, 90; while the occupation of 94 others is unknown.

There are now (1880) in college 228 students in classes, as follows: first class, 20; second class, 18; third class, 57; fourth class, 59; preparatory department, 74.

No law of the college excludes women, but public opinion prohibits them from sharing its benefits. The faculty have brought this matter to the attention of the board of trustees, and have expressed their almost unanimous desire that women should be invited to enter the college; but the board has not seen proper to adopt their recommendation.

For information as to the means for practical application of instruction, you are respectfully referred to the reports of the professors of chemistry, agriculture, and engineering, and the commandant of the college, herewith submitted.

Very respectfully, your obedient servant,

I. T. TICHENOR,
President.

The following statements accompany President Tichenor's report:

Statement of the professor of agriculture.

I present herewith an outline of the course of study in the agricultural department of this institution. The course requires four years for its completion, entitling the student who stands an approved examination in all the studies embraced in it to the degree of "bachelor of scientific agriculture."

The first two years of the course are devoted to studies which are common to the usual college course in the freshman and sophomore years, except that modern languages (French and German) may, if the student elects, be substituted for Greek and Latin. The last two years are devoted to technical instruction, embracing the following subjects:

(1) Mechanics and physics, in which the class makes daily recitations during the first term (five months) of the junior year.

(2) Botany, two recitations weekly during the second term of the junior year.

(3) Descriptive astronomy and meteorology, three recitations weekly during the first term of the senior year.

(4) Geology and mineralogy, three recitations weekly during the second term of the senior year.

(5) Zoölogy and entomology, two recitations throughout the first and second terms of the senior year.

(6) Agricultural chemistry, with practical instructions in qualitative and quantitative analysis of soils and fertilizers, to which two hours are devoted daily throughout the first and second terms of the junior year.

(7) Vegetable physiology, embracing the structure and habits of plants and their relations to the soil and atmosphere, occupying two recitations weekly during the first and second terms of the senior year.

(8) Practical agriculture, embracing the subjects of soils, drainage, cultivation, irrigation, fertilization, farm-crops, farm-implements, farm-animals, fruit-culture, market-gardening, floriculture, and landscape gardening; in which daily recitations are required during the whole of the two years.

In addition to the technical studies embraced in this course, the class in agriculture is required to make three recitations weekly in the second term of the senior year in political economy, and to attend weekly lectures upon constitutional law, the law of contracts, conveyancing, and landlord and tenant, in which it is designed to furnish such instruction on these subjects as will be of service to the practical agriculturist.

For the purpose of illustrating and applying the principles taught in the text-books and lectures, the college is furnished with the following appliances:

(1) Extensive mineralogical and geological cabinets, and a museum of natural history.

(2) A commodious laboratory, fitted up for lectures and work in analysis, supplied with furnaces, balances, gas and water, and twenty-five work tables, each furnished with necessary chemicals and apparatus.

(3) An experimental farm of twenty acres, devoted to soil-tests of fertilizers and experiments in the cultivation of field crops, grapes, fruits and flowers, conducted under the supervision of the professor of agriculture, with practical instructions to the class during the junior and senior years.

Respectfully submitted.

W. H. CHAMBERS,
Professor of Agriculture.

Statement of the professor of engineering.

In the first year of the course of four years we teach practical drawing on the plan pursued in the English schools; in the second year, the practical use of the chain, compass, theodolite, and engineers' leveling instruments is thoroughly taught in the field for farm and land surveying, ditching, and leveling.

Drawing, in the second year, includes practical work on farm maps, drawing from models, shades, shadows, structural drawing, and topographical delineation; in the third and fourth years, at least two hours each day in completing a course in projection and perspective. Graphical skill is cultivated in depicting, in conventional colors, machines, bridges, furnaces, water, gas, and railway structures. Plans, profiles, and sections of railroad surveys complete a very full and practical course of industrial drawing.

The practical work in surveying begins in the second year of the course. All students of this year are exercised in the use and adjustment of the plain and solar compass, of the theodolite, sextant, engineer's leveling instruments, and the various styles of leveling rods. Individual practical instruction is given to each member of the class in the practice of surveying, locating, and division of lands, and in leveling ditches, gradients, terraces,

farm, water, and railroad levels. Tracing railroad curves and subterranean lines in mining work is practically taught as part of the general course for all students of the second year.

Technical engineering is taught only to those students who have completed the general course of two years. A full course in chemistry, physics, and pure mathematics, with an elective course in either ancient or modern languages, is the basis of the course in engineering.

Mechanics, particularly the theory of strength of materials and of strains in roofs and bridges, with full instruction in regard to the construction of roads, railroads, bridges, canals, improvements of rivers and harbors, complete the work of the last two years of the course.

In aid of the practical studies of the college, and as a means of familiarizing students with the actual details of work, the second class in engineering devote two weeks in December, and the first class four weeks in April, to field work and to visits of inspection to machine-shops, mills, mines, furnaces, and engineering constructions within convenient reach. Geological students are afforded in vacation each year an opportunity of accompanying the State geologist in his excursions. In the past scholastic year the second class in engineering has visited and inspected the cotton and woolen mills, founderies, machine-shops, bridges, and gas works in and near Columbus, Ga. The first class in engineering inspected the founderies, workshops, gas and water works of Montgomery, and the iron region lying along the South and North Railroad.

R. A. HARDAWAY,
Professor of Engineering.

Statement of the professor of chemistry.

This department occupies four rooms: a lecture-room, a working-room, a furnace-room, and a balance-room.

The lecture-room is 40 by 40 feet, and is provided with a counter, pneumatic trough, copper gasometer, water basins, blackboards, shelves with glass cases, gas jets, blow-pipes, and all the necessary apparatus for illustrating a general course in theoretical chemistry.

The working-room is 36 by 24 feet and has 24 work-tables, each one supplied with a full set of reagents, a drawer, a gas jet with Bunsen's burner, and such other apparatus as is necessary to make all the analyses required in a full course on agricultural science. The balance-room contains two sets of balances with weights, one made by Becker of New York, the other by Oertling of London. The furnace-room is provided with a temporary furnace, furnishing an air-bath, water-bath, sand-bath, and a still for distilling water. There are also small furnaces for assaying and organic analysis.

Water and gas are supplied in every part of this department; and a constant Watson's battery, furnishing electricity to all the bells of the college, is kept in the lecture-room.

The instruction given in this department consists of (1) a general course in chemistry to all students; (2) qualitative analysis, given to students in agriculture and science; (3) quantitative analysis, including both gravimetric and volumetric, given to students in agriculture and science, and (4) agricultural chemistry, given only to agricultural students. The text-books used are Bloxam's Chemistry, Church's Laboratory Guide, Caldwell's Agricultural Analysis, Mott's Manual of Chemistry, Johnson's How Crops Grow and How Crops Feed.

The course in general chemistry requires five hours a week to complete it; that in agricultural chemistry three hours a week; three years are required.

Respectfully submitted.

WM. C. STUBBS,
Professor of Chemistry.

Statement of the commandant and military instructor.

The practical work in the military department consists of daily drills in the school of the soldier, squad, company, and battalion; guard duty is required of all cadets capable of bearing arms.

The text of Upton's Report on Tactics, revised edition, through the "school of the soldier" is learned by heart by every cadet, and each is required to repeat it verbatim. The school of the company and battalion, the parades, honors, &c., are recited by all cadets, illustrated by demonstrations on the blackboard, but only the "school of the soldier" is required to be recited literally.

In addition to recitations in Upton's Tactics, lessons in organization, supply, transportation of armies, fortification, strategy, target-practice, and ordnance are recited by the cadets and illustrated by the professor. This is a four years' course.

R. A. HARDAWAY,
Colonel Commanding.

Supplementary information.

From the catalogue of 1880–'81, it appears that a professor of English literature has been added to the faculty. The number of students registered is 182, in classes as follows: first class, 15; second class, 23; third class, 34; fourth class, 63; fourth class, section A, 47. The twenty graduates in 1880 make up the whole number of alumni to 62; of these twenty, six took the degree of A. B.; two B. S.; three, B. S. A.; and nine, B. E.

The requirements for admission to the college embrace the common-school studies, elementary algebra and English history; to these must be added, by those who are candidates for the degree of bachelor of arts, in Latin, four books of Cæsar and six of Virgil's Æneid; in Greek, two books Xenophon's Anabasis. All students pursue the same course for two years, except that those in other than the literary course may take French and German in place of Latin and Greek, and must take drawing. At the end of the two years the students choose between courses in agriculture, civil engineering, mining engineering, literature and science.

There appears to be a recent modification of the course in civil engineering for the purpose of giving students an opportunity to become familiar with mining. Special instruction is introduced in mining, preparation of ores and their metallurgical treatment. Geology and mineralogy receive considerable attention. An additional year of study is required of those who would obtain the degree of mining engineer, that of bachelor of mining engineering being given at the end of the fourth year.

ARKANSAS.

INDUSTRIAL UNIVERSITY.

FAYETTEVILLE, ARK., *March* 30, 1881.

SIR: The chief end of the Arkansas Industrial University is to afford a cheap practical education to the industrial classes, but especially to teach them agriculture and the mechanic arts.

The endowment funds consist chiefly of the grant of land by the general government, in the donations of $100,000 by the county of Washington, Ark., and $30,000 by the town of Fayetteville. The grounds and buildings are valued at $170,000. The annual income is $10,400 from the bonds of the county and town aforesaid, $2,000 from tuition fees, and an average of about $5,000 from the legislature; annual expenditure, about $17,500. Professors' salaries consume about $15,500 of this sum.

The professors and instructors are as follows: (1) president and professor mental and moral science; (2) principal of normal department; (3) professor of mathematics (instructor in tactics); (4) professor of natural sciences and chemistry; (5) professor of civil and mechanical engineering; (6) professor of natural sciences; (7) professor of military science and tactics (not appointed as yet); (8) professor of physics and astronomy; (9) teacher of drawing and painting; (10) professor of ancient and modern languages; (11) professor of English literature and history; (12) professor of music, aided by competent assistants; (13) principal of preparatory department; (14) preceptress of preparatory department; (15) first assistant preparatory department; (16) second assistant preparatory department; (17) third assistant preparatory department.

The number of enrolled students this session (including the medical department) is 473; of these, two-thirds are males. The college fees are almost nominal, the majority not paying more than $5. All expenses, including boarding, clothing, books, &c., do not exceed $200 to the majority of the students. The board grants free tuition to 600 beneficiaries and 400 normal students sent from the various counties according to population. Not more than one third of these appointments are claimed by the respective counties. Our graduates do not exceed eight or ten annually. They take generally the A. B. or B. S. degrees, though a few take the normal degree. About one-fourth of the graduates are females.

We have a classical course differing not materially from that in most colleges; an agricultural course identical with that in the agricultural and mechanical colleges, giving agriculture prominence in the curriculum; a scientific course, prominence being given to mathematics, engineering, and mechanical philosophy; and a normal course specially devoted to the training of teachers.

There is not now, nor has there been, any special instruction for young women. I have felt the need of a curriculum adapted to their mental characteristics. Some of them have been found with taste and talent for the higher mathematics.

We have no workshops, and practical mechanics receive no illustrations. In fact the

farm work itself is on a small scale. The State in its poverty has not felt able to build workshops or suitably to equip a farm.

Very truly yours,

D. H. HILL, *President.*

Hon. JOHN EATON,
Commissioner of Education.

It will be observed that the first nine instructors specified in the foregoing list are more related to the college of agriculture and the mechanic arts than the remainder.

From the annual catalogues of the university the following facts are gathered:

STUDENTS.

The number of enrolled students for the year ending June, 1881, was 441, of whom 411 were from Arkansas, 8 from Missouri, 8 from Louisiana, 5 from the Indian Territory, 2 from Texas, and the rest (1 each) from several other States. The "academic" (collegiate) department enrolled 120, and the normal classes 82. Many students are enrolled in two or more branches of the institution.

TUITION.

The fees are $5 for matriculation; students other than normal or beneficiary also pay $10 per term; there are three terms each year, covering forty weeks in all. Tuition in the university proper is free.

FREE SCHOLARSHIPS.

The trustees, under legislative authority, have created 600 beneficiary and 430 normal appointments. In addition each county can appoint each year one honorary scholarship from among the meritorious students of the public schools therein. Sixty scholarships are also open to scholars from any part of the State.

STUDIES.

Particular notice of the studies of the classical, Latin, letters, modern languages, English, and normal courses would not be in the province of this report. The scientific, the two engineering, and the agricultural courses are industrial in their direct bearings. The studies of the subfreshman year preparatory to these courses are the same, namely, algebra, French, German, drawing, and English composition. The studies common to the four courses during freshman year are English, algebra, geometry, physical geography, physics, drawing, and German. Those not in other than the agricultural course take French, and those in the civil engineering course omit botany. Sophomore year the courses continue nearly parallel. Their common studies are trigonometry, general and analytical chemistry, blowpipe, analytical geometry, surveying and navigation, and German. The civil engineering course omits botany and zoölogy, which are common to the others. The common studies of the junior year are analytical geometry, geology, mineralogy, and analytical chemistry. The other studies are as follows: Scientific course, physiology, biology, and anatomy; civil engineering course, applied mathematics and calculus; mining engineering course, applied mathematics; agricultural course, physiology, stock breeding, entomology, anatomy, astronomy, book-keeping, agricultural chemistry, and machinery. In the senior year the studies of the civil engineering course are natural philosophy, industrial chemistry, and applied mathematics. The mining course added analytical chemistry to these studies, and the scientific course substituted it for applied mathematics. The studies of the agricultural course are more numerous, including, besides analytical and industrial chemistry, physics, agriculture, landscape gardening, and veterinary surgery.

Degrees are given to those who have successfully completed the several courses, as follows: Classical course, A. B.; scientific course, B. S.; agricultural course, B. Agr.; civil engineering course, C. E.; mining engineering course, M. E.; Latin letters course, B. Lat. letters: modern languages course, Bach. Letters; English course, Bach. Eng. Letters.

The following additional information, gathered from the annual reports, gives the general scope of the technical and special work pursued:

Military: Instruction in this department is designed to impart to each male student not physically incapacitated to bear arms practical instruction in the school of the soldier, of the company and of the batallion, the duties of guards, outposts, and pickets. The drills occur not over three times a week, and being short they involve no hardship, while it is manifest

that they afford a good health-giving exercise and aid in the development of the physique and manly carriage of the student.

Chemistry: Chemical physics is studied by the students of all the courses during the first term of the sophomore year; it embraces the physical principles requisite to the pursuance of chemistry.

Inorganic chemistry: The course embraces three hours a week recitation and ten hours a week laboratory work. The important chemical elements and their principal compounds are considered as to their occurrence in nature, physical and chemical properties, methods of manufacture, prominent uses. About three hundred experiments illustrating important chemical principles are individually performed.

Organic chemistry is pursued by applicants for all the degrees excepting the A. B. (bachelor of arts).

An experimental farm of excellent character has been provided, immediately contiguous to the university, for agricultural and horticultural purposes. The labor system will be under the direction of the board of trustees, but students will not be required to labor more than ten hours per week. Compensation for labor will be from 2 to 10 cents per hour, according to ability.

All male students appointed as beneficiaries are required to take a course in agriculture or mechanics, "with permission to select such other studies as circumstances may allow."

Students in all departments are required to pursue not less than three distinct studies.

The university library, though small, is increasing and comprises some valuable works. The legislature makes small appropriations, the last being $1,000 in 1879–'80.

The cabinet and museum are small as yet, but the collections slowly increase. The philosphical apparatus, though not large, is excellent. Female students are admitted to all the departments. There were in 1880 in the classical course, 3 in the senior class, 1 in the junior class, 0 in the sophomore, and 21 in the freshman. In the preparatory department there were 67.

CALIFORNIA.

UNIVERSITY OF CALIFORNIA.

[Statements from the recent registers and bulletins.]

The University of California was established by a law which received the approval of the governor early in 1868. It was opened at Oakland in the autumn of the following year. In 1873 it was transferred to its permanent home at Berkeley. The college of California, which had been organized several years before, transferred its property and students to the new university, and closed its work of instruction when that of the university began.

The university has for its object general instruction and education in all the departments of science, literature, art, and industrial and professional pursuits, and special instruction in military science and for the professions of agriculture, the mechanic arts, mining, civil engineering, law, and medicine.

The funds by which the university is maintained are derived from various sources and include the following endowments: (1) The seminary fund and public building fund, granted to the State by Congress. (2) The property received from the College of California, including the site at Berkeley. (3) The fund derived from the Congressional land grant of July 2, 1862. (4) The tide land fund, appropriated by the State. (5) Specific appropriations by the legislature for buildings, current expenses, &c. (6) The gifts of individuals. The amount received from the sale of the Congressional land grant of 1862 was $750,000.

The latest information received (1880) gives the following financial exhibit: Value of grounds, buildings, and apparatus, $805,000; amount of productive funds, $1,671,204; income from productive funds, $99,216; receipts from tuition fees, $200; receipts for the last year from State appropriations, $36,600.

COLLEGES.

The scientific departments are five in number, and consist of the colleges of agriculture, mechanics, mining, engineering, and chemistry.

The faculty is as follows: President of the university (also professor of physics); professors of the Latin language and literature; of the Greek language and literature; of history and political economy; of the English language and literature, of industrial me-

chanics; agriculture, agricultural chemistry, and botany; geology and natural history, chemistry; civil engineering and astronomy; mathematics; instructors in Latin, English, French, German, engineering, chemistry (2), quantitative and qualitative analysis; industrial drawing, mining, metallurgy; mathematics (2); mineralogy, physics and mechanics, and chemistry. Also a superintendent of the physical laboratory, assistant in agricultural laboratory, lecturer on practical agriculture, and lecturer assistant in chemistry. Besides these there are seven instructors in the literary branches.

The academic senate consists of all the faculties of all the colleges of the university.

STUDENTS.

The number of students who have been in attendance at the university in each year since its opening in 1869 is as follows:

Years.	Science.	Letters.	Special and at large.	Total.	Ladies.
1869–'70	14	21	5	40	.....
1870–'71	28	24	26	78	8
1871–'72	75	28	50	153	27
1872–'73	93	44	48	185	39
1873–'74	100	44	47	191	22
1874–'75	95	73	63	231	38
1875–'76	134	138	38	310	42
1876–'77	126	140	39	305	45
1877–'78	117	149	52	318	51
1878–'79	122	142	68	332	55
1879–'80	79	120	69	268	55
1880–'81	71	96	79	246	59

Of the 71 in the colleges of science in 1880–'81, 21 were in the freshman class, 17 in the sophomore class, 18 in the junior class, and 15 in the senior class. The course of study during freshman year is common to all the colleges of science. At the beginning of the second year choice of course is usually made. Those continuing in science beyond the first year numbered in 1880–'81 4, of whom 2 were sophomores and 2 juniors. The students in the college of agriculture were 9. Of these 4 were sophomores, 3 juniors, and 2 seniors. Two sophomores, 2 juniors, and 7 seniors took the course in mechanics. The students in mining were: sophomore, 1; juniors, 3; seniors, 2; in all 6; in engineering: sophomore, 6; juniors, 4; senior, 1; in all, 11; in chemistry: sophomores, 2; juniors, 4; seniors, 3; in all, 9.

The students at large numbered 21, of whom there were in the college of chemistry, 2; mechanics, 1; general scientific course, 3; engineering course, 1.

The special students numbered 23, of whom there were in the college of agriculture, 2; chemistry, 5; mining, 5; engineering, 1; general course, 2; in all the scientific courses, 15. There were 35 pursuing partial courses, of whom 6 were taking agriculture; 1, engineering; 2, chemistry; and 2, general science. Tuition is free to residents of California; students from other States pay a matriculation fee of $25 and a tuition fee of $50 per year.

The following degrees have been conferred (to 1879 inclusive): bachelors of arts, 73; bachelors of philosophy, 137; total, 210.

By a recent bulletin it appears that the degree of bachelor of science is now given to those completing the undergraduate courses in science. Higher professional degrees are given to those who complete prescribed courses of higher study.

Women are admitted to all the colleges. Their attendance is chiefly in the classical and literary courses.

UNIVERSITY APPLIANCES AND COLLECTIONS.

Laboratories.—A large amount of space is devoted to the chemical laboratories. They are planned after the very best models. A physical laboratory is already organized.

Philosophical apparatus.—The cabinet of apparatus for the experimental demonstration of the laws of physics and mechanics is very complete.

An observatory has been provided for, through the benefaction of the late James Lick, esq.

The library contains about 20,000 books and pamphlets.

The collections illustrative of science which belong to the university are large and valuable and are adapted to the wants of students seeking a scientific or technical education. They are made up from material derived mainly from the State geological survey;

the Voy collection of California fossils, minerals, and rocks; the Pioche collection of rocks, ores, minerals, shells, &c., gathered in all parts of the world, but largely in South America; and the Hanks collection of minerals. These collections are given the names of their collectors. Current donations and purchases by the university do much to increase the value and extent of the means of illustration. The collections are divided among museums of classical archæology, ethnology, zoölogy, botany, geology, mineralogy, and ore deposits. The museum of ore deposits was founded in 1879. It is expected that it will fulfill the twofold purpose of rendering possible a course of instruction to mining engineers in ore deposits, and of affording an opportunity for the general study of the deposits of the Pacific coast. The museum of classical archæology contains a cabinet of medals and coins. There are also sets of ancient war maps and pictures of ancient life, customs, and architecture.

The museum of ethnology contains stone implements, skulls, ancient wooden tools, and Peruvian pottery.

The museum of zoölogy embraces a small collection of mammals, birds, reptiles, fishes, mollusks, and radiates.

The museum of botany has a valuable herbarium of Australian plants, collections of native wood cones, cereals, and photographs of California trees.

Professor Hilgard has placed his private collection of some 12,000 specimens of American and foreign plants in the lecture room of the college of agriculture for the use of students.

The museum of geology is divided into departments of paleontology and lithology. The first comprises the Whitney collection of California animal fossils and the collection of plants recently made by Mr. Lesquereux.

The lithological collection embraces extensive representations from notable localities, and especially so of the rocks of California, eruptive and stratified.

The museum of mineralogy contains many specimens from the Eastern States and Europe, and a very full exhibit of minerals of the Pacific coast.

An agricultural museum is now being arranged, and already contains many indigenous and exotic woods and specimens of the flora of the State. A cabinet of the soils, agricultural products, and manufactures of the State is being formed.

The plants, &c., of the State geological survey are also in possession of the university and available for agricultural students. The agricultural grounds are being prepared and occupied as rapidly as the finances permit. A standard orchard, embracing 600 varieties, is now bearing. An experimental station, embracing 13 acres, is in use. Part of it is permanently occupied as a garden of economic plants. A garden of general botany is being laid out. There are three propagating houses, with other necessary buildings.

The regents have recently appropriated funds to commence an industrial survey of the State, under the direction of the professors of agriculture, chemistry, &c.

The college of mining has been further equipped (during 1879) with a complete metallurgical laboratory. Its students have full access to the chemical and physical laboratories and collections.

The college of mechanics is being equipped with a special laboratory and model room, which will also be open to the students in mining.

The college of engineering possesses a suitable collection of surveying instruments, models in wood of walls, bridges, arches, &c.; also in joints in carpentry and frame work, of bridge and roof trusses, diagrams of famous structures, and the hypsometrical and surveying apparatus formerly belonging to the State geological survey.

The college of chemistry possesses the necessary appliances, laboratories, &c., to make the work of study effective and practical.

The course in military science, required of all the students not physically disqualified, includes tactical instruction in book and field, lectures on the art of war, and practical study of fortification, &c., as afforded by the United States post at San Francisco and its extensive forts, garrisons, arsenal, and other appliances.

The opportunity for field and operative study in agriculture, mining, mechanics, engineering, and manufacturing chemistry afforded by the great industrial resources and enterprises of California are being freely made available by organized visits of inspection and other modes of study and observation.

The United States Coast and Geodetic Survey, the surveys and operations of United States engineers in the harbors of the coast, and the extensive works of the hydraulic mines, the irrigation, engineering, &c., are all used for illustration and instruction.

STUDIES.

There are eight regular courses of study in the university proper, namely, classical, literary, letters and science, and five scientific courses, and three irregular courses, namely, student at large, special, and partial. The classical course leads to the degree of bachelor

of arts and corresponds to the usual academic course of the leading American colleges. It is designed to offer the best preparation for professional study and to furnish a liberal education.

Both Latin and Greek are required for this course.

The literary course leads to the degree of bachelor of letters and has the same general purpose as the classical course. It is designed for students who wish to study Latin and to enjoy a fuller course in English, French, and German than that offered by the classical. Greek is not required.

The course in letters and science leads to the degree of bachelor of letters, and in it special attention is given to the English language and literature, to modern languages, history, and political science. It is especially intended for students who wish a liberal course in general culture. Neither Latin nor Greek is required.

The student-at-large course does not lead to a degree; but students in it may, by vote of the faculty, be recommended to a degree upon the satisfactory completion of studies equivalent to those pursued in one of the regular courses. It is designed for students who wish to take a full but a purely elective course. They select studies from any of the courses, provided they satisfy the faculty that they are fitted to take the studies selected. Candidates for it are required to pass one of the regular admission examinations, and upon admission to take studies enough to make up the full number of exercises required of students pursuing a regular course. Students who fail to maintain their standing as regular students are not admitted.

The special course does not lead to a degree; but students in it may, upon leaving the university, receive a certificate of proficiency in the studies which they have pursued and in which they have attained marked scholarship. It is designed for students who are mature, and who wish to pursue some line of special study and correlated branches. Students under age are not ordinarily admitted. Applicants who fail on the admission examinations or students who fail to maintain their standing as regular students are not admitted.

The partial course does not lead to a degree; but students in it may, upon leaving the university, receive a certificate of proficiency in the studies which they have pursued and in which they have attained marked scholarship. It is designed for students who, because of ill health or other disability, are able to pursue only a limited number of studies or to remain at the university only a short time.

Applicants are not admitted to this course until they have passed a satisfactory examination on such preparatory subjects as may be thought necessary to fit them for the studies they wish to pursue.

The courses in science are those of agriculture, mechanics, mining, engineering, and chemistry. They are designed to give the student a good English education and an introduction to the principles of modern science, together with special instruction preparatory to a fuller course of professional study in the particular department he may choose. Neither Latin nor Greek is required in them, but a preparatory course in Latin is recommended.

The course in agriculture is designed for students who wish to familiarize themselves with the sciences which underlie the farmer's calling and with the best practice of its several branches. It is arranged with a view to preparing them for the intelligent and successful exercise of their profession as practical farmers or agricultural experts. The instruction obtained from text books, recitations, and lectures is supplemented by visits to orchards, vineyards, farms, and dairies, and by the experiments conducted on the university farm.

The special instructors of the college of agriculture are a professor of agriculture and related subjects, a lecturer, who has charge of the experimental grounds, and two assistants in the laboratories.

The course of study under the regular professor begins with botany in the sophomore year. Much time is given to the description and study of plants useful and injurious to agriculture. From economic botany the student passes to agricultural chemistry and the theories of culture and the maintenance of fertility, which are the special studies of the junior year. During the senior year lectures are given and studies pursued which treat of the fundamental branches of agriculture, such as stock breeding, dairying, farm machinery, drainage and irrigation, and general field crops. The laboratories of the college are intended to aid in the investigation of questions in practical agriculture, principally by the examination of soils and products. In this way the best methods of increasing fertility, the value of manufactures relating to agriculture, the nature of the diseases of crops, can be ascertained, and adaptation of plants and the usefulness or injuriousness of insects can sometimes be determined. The benefits of the practical work of the college are available to farmers, as the professor in charge is ready to give prompt answer to inquiries that come within the sphere of his labors.

The course in mechanics is designed for students who intend to become mechanical

engineers or machinists (so far as they are constructors of machinery) or to devote their energies to such technical and industrial pursuits as involve a knowledge of machinery. The course of study peculiar to the college commences with the junior year. Its special studies during that year include the applications of differential and integral calculus, the laws governing the rest and motion of points, bodies, and systems of bodies, and the determination of strains in structures. In the senior year hydrostatics, hydrodynamics, the regulation and accumulation of motion, and the determination of forces are considered; and a post-graduate year is devoted largely to the theory and construction of machines and to steam and steam engines. The acquaintance with drawing which the student has acquired during the previous years of general study is now utilized in drawing plans for machinery and in representing motion and the means for modifying it. No mention of a shop appears in the reports received from the university. It is presumed that actual work on machines is conducted in the mechanical laboratory, which is well equipped for practical instruction.

The course in mining is designed for students who wish to become mining or metallurgical engineers, or to engage in one of the many pursuits connected with the mining industries, such as the surveying and mapping of mines, the assaying and working of ores, the designing and use of mining machinery, or the exploitation of mines. The first two years of the undergraduate's course are nearly the same as that of the other scientific colleges of the university. A certain amount of the second year is, however, devoted to more special work, such as qualitative analysis, blowpipe analysis, land and mining surveying and leveling, industrial drawing, &c. The instruction given in these studies is practical as well as theoretical, the laboratories, instruments, and grounds of the university furnishing excellent facilities for this purpose.

During the last two years the instruction is more directly connected with mining, attention being given to analytical chemistry, analytical and applied mechanics, mineralogy, geology, mining, metallurgy, and assaying. While the scientific studies are not taken up in a merely technical way, they are taught as far as possible with reference to their applications to mining and metallurgy, and the entire course of the last two undergraduate years is overlooked by the instructor of mining and metallurgy, under whose special guidance the mining students come.

Students are encouraged throughout the course to visit the industrial establishments of San Francisco, Oakland, and vicinity, and to visit and study on the spot mines and smelting works at greater distances during vacations.

The course of study for post-graduate students in this department is being organized as fast as the means of instruction become available. It will include the studies of petrography, economic geology, crushing, separating, and mining machinery, political economy, and mining law, together with original work on the part of the students with ores, metallurgical processes, machinery, &c., for which the metallurgical and mechanical laboratories will offer excellent facilities.

The course in engineering is arranged for students expecting to adopt civil engineering as a profession, and to engage in such work as the survey of lands, leveling, topographical engineering, geodetic surveying, the location and construction of roads, railways, and canals, the designing and construction of bridges of wood, iron, or stone, the building of dams, reservoirs, and systems of water supply, drainage and sewerage, and the improvement of rivers, harbors, and seacoasts.

The special instruction in engineering begins in the sophomore year with the surveying course. This includes land and topographical surveying, leveling, the use of the plane table, road and railroad surveying and construction, with computation of earthwork required by excavations, tunnels, and embankments. A liberal amount of time is allotted, to practice in the field and to the use of instruments and in the working up and plotting of field notes.

Topographical drawing and map making are taught, and sketches made of the surrounding country. The work of the fourth year is chiefly professional. The subjects treated include the characteristics and properties of the various building materials, their strength, uses, and different methods of employment in structures; the rules governing the construction of works of masonry; problems relating to the more difficult constructions, such as groined, cloistered, rampant, and skew arches and domes, and walls bounded by warped surfaces; and the principles and practice of framing, bridge and truss building, the preparation of estimates and working plans. The solution of a problem in engineering terminates the undergraduate course.

The post-graduate course is three years in length, and leads to the degree of civil engineer (C. E.). The appliances are well chosen and sufficient for the practical illustration of the branches pursued.

Surveying instruments, models of structures, and the apparatus belonging formerly to the geological survey make up a large part of the collection.

The course in chemistry is designed for those who wish to become professional chemists,

either as teachers or investigators, or manufacturers in chemical industries; and also for those intending to become expert chemists preparatory to the pursuit of medicine or pharmacy. Special teaching begins with the second term of the sophomore year, during which elementary instruction in general and theoretical chemistry is given by means of lectures, recitations, and laboratory practice.

In the junior year the course is continued, and the application of the science to mineralogy and metallurgy is made prominent.

Senior year is specially devoted to organic chemistry. The laboratory work is required to be carefully and systematically performed. After a satisfactory completion of the work in qualitative analysis by the blowpipe and in the wet way, the student passes to quantitative work, and receives practice in the analysis of gases, salts, ashes, mineral waters, and other substances, and in the preparation of organic and inorganic compounds. Special attention is paid to the analysis of mineral waters and agricultural fertilizers, and to electrometallurgy. The students are encouraged to visit the chemical and metallurgical works in the vicinity, and have many advantages in the way of lectures and laboratory practice in the various departments of the university.

COLORADO.

STATE AGRICULTURAL COLLEGE.

[From letters, circulars, &c., received by this office.]

This institution, located at Fort Collins, Colo., is founded on the national land-grant benefaction, and its leading object is to impart a thorough and practical knowledge of all those branches and sciences that pertain to agriculture and the mechanic arts. The endowment consists of 90,000 acres of land, selected "in place" by the State under the agricultural college land grant acts of 1862, 1864, and 1866. The land remains unsold, and if properly disposed of will doubtless result in the establishment of a large permanent fund.

The college is now supported by a biennial appropriation of the State legislature. The appropriation made in 1881 was $\frac{1}{5}$ mill tax on State valuation, or about $20,000 annually.

LOCATION, BUILDING, AND APPLIANCES.

The college building at Fort Collins is well arranged and ample for present uses. The locality has many advantages, and is thus described: Fort Collins is located on the southern bank of the Cache la Poudre, about 6 miles east of the foot-hills of the Snowy Range and 35 miles south of the State line; it is surrounded by a fertile and well-watered region, including some of the best agricultural lands of the State. Its elevation of 5,100 feet above the level of the sea gives it a pure, dry atmosphere, while its proximity to the mountains brings it within the limit of occasional rains, thus rendering the climate pleasant and salubrious and adapting the soil to the cultivation of the cereals. This region, comprising the counties of Larimer, Weld, Boulder, and parts of Arapahoe and Jefferson, is rendered accessible from the north and south by the Colorado Central Railroad, which passes directly through Fort Collins, and the Greeley, Salt Lake and Pacific, just completed from Greeley, both of which roads connect with the Union Pacific at Cheyenne and with the Kansas Pacific at Denver. The streams draining this region, the Cache la Poudre, Big Thompson, and other tributaries of the South Platte, furnish an inexhaustible supply of water for purposes of irrigation. It is estimated that the great irrigating canal, now in process of construction and supplied from the Cache la Poudre, will bring at least 100,000 acres of unproductive land under cultivation. The college has been most judiciously located with reference to this large extent of farming land, in the midst of communities refined and progressive and very fast surrounding themselves with all the comforts of the most advanced localities in the West.

The president writes, under date of April, 1880, that, "during the winter vacation, the faculty of the college, and such members of the State board of agriculture as can accompany them, travel over the State, holding farmers' institutes at eligible places. These institutes consist of a course of lectures by members of the State board, the faculty, and resident farmers on topics connected with farm or garden work. Five of these institutes were held during the past vacation at Fort Collins, Greeley, Longmont, Monument, and Del Norte, and were well attended by farmers and others."

A more complete account of this branch of the work of the college, given in the catalogue for 1881, is as follows: "To give a clearer idea of the work at these institutes, we

append a programme of places and topics: Fort Collins, November 26 and 27, 1879, and December 9 and 10, 1880; Del Norte, December 30 and 31, 1879; Monument, January 2 and 3, 1880; Greeley, January 15 and 16, 1880; Longmont, February 5 and 6, 1880; Loveland, December 16 and 17, 1880; Denver, January 5 to 8, 1881. All the members of the faculty attended these institutes and read papers or gave lectures on the following topics: Ex-President Edwards, the utility of trees, tree culture, relations of the Agricultural College to the State, book farming and hygiene of the farm; Prof. A. E. Blount, corn and its culture, seeds, wheat culture, injurious and friendly insects, milling properties of wheat, hybridization and cross-breeding; Prof. F. J. Annis, soils and their analysis, relative food value of flour, the farmer's home; Secretary H. Stratton, dairying, amber cane. The following members of the board furnished lectures on the annexed topics: W. E. Watrous, fruit culture, strawberries; B. S. La Grange, construction of ditches, irrigation; J. S. Stanger, relation of grasses to agriculture, Colorado as a home for farmers, diversification and marketing of crops, the necessity of improved farming; S. W. Homer, irrigation; P. M. Hinman, wheat.

The dormitory was erected in 1881, and will accommodate 30 students, or 25 students with officers assigned for care and duty.

A small building now used for chemical laboratory is well fitted and supplied with all needful apparatus for work. It will accommodate 12 students, classes working in two sections.

Ample work in qualitative and quantitative analysis is given, while with the new assay furnace just added excellent work in that line can be done.

The department of mechanics and drawing was opened to students September 12, 1882. The shop is fitted for doing bench work in wood and iron, while an adjoining room is used for forge work. Sixteen students are now taking this work, and more would be pleased to do so were there an opportunity. A building has been erected containing basement and one and one-half stories, which is soon to be used for mechanics. Within two months power will be supplied and machinery put in, which will give an opportunity for our students to complete the course in mechanics by taking wood-turning, scroll and fret sawing, while pattern making will lead to the course in iron work upon lathes and planes.

FACULTY.

The faculty consists of a president, who is professor of logic and political economy; professor of agriculture and botany, who is also superintendent of the farm; professor of chemistry and physics; professor of mechanics and drawing, who is superintendent of the shops; a secretary; a superintendent of the department of horticulture; a superintendent of floral department; and a matron of the ladies' dormitory.

STUDENTS AND TUITION.

The first college class was formed November 28, 1879, and consisted of 23 students, of whom 7 were women. The number of students in attendance in the year ending in 1881 was 57, of whom 25 were ladies; in 1882, 56.

Tuition is free to all residents of the State. A matriculation fee of $5 and an incidental fee of $1 per term entitle the student to all the privileges of the college.

There are as yet no scholarships provided.

STUDIES.

Preparatory year.—First term: Arithmetic, United States history, physical geography, English analysis. Second term: Arithmetic, United States history, elocution, physical geography, elementary physiology, English analysis. Third term: Elementary algebra, elocution, elementary physiology, word analysis. Throughout the year two hours of daily labor are required on the farm or garden.

Freshman year.—First term: Algebra, elementary rhetoric, drawing, agricultural lectures. Second term: Geometry, bookkeeping, drawing, botany. Third term: Higher algebra, ancient history, drawing, botany. Two hours of daily labor on the farm or garden are required throughout the year.

Sophomore year.—First term: Geometry completed, history continued, drawing, elementary chemistry. Second term: Trigonometry and surveying, English literature, drawing, organic chemistry, and blowpipe analysis. Third term: Physics, English literature, drawing, zoölogy. Throughout the first and second terms there are two hours of daily shop practice in mechanics; in the third term, field surveys and levelling.

Junior year.—First term: Physics, rhetoric, geology, agricultural chemistry. Second term: Chemical physics, floriculture, anatomy and physiology, agricultural chemistry. Third term: Meteorology, horticulture, physiology, entomology. During the first and

second terms there are two hours of daily laboratory work in chemical analysis; during the third term, two hours on the farm or garden.

Senior year.—First term: Botany, stock breeding and food stuffs, veterinary science, psychology. Second term: Astronomy, household economy, veterinary science, logic. Third term: Moral science, landscape gardening, United States Constitution, political economy. Throughout the year there are two hours of daily shop practice in mechanics.

THE FARM AND GROUNDS.

The college farm includes 240 acres, most of which is under cultivation, the work being chiefly experimental, and including the culture of trees, small fruits, cereals, garden vegetables, &c.

The trees under successful cultivation include the standard varieties of apple, pear, plum, and cherry; and of forest trees, the ash, box-elder, chestnut, elm, locust, maple, and willow. The small fruits are represented by blackberries, currants, gooseberries, grapes, raspberries, and strawberries.

The floral department is an interesting and attractive feature of the college. The grounds adjoining the building have been terraced and grassed, and adorned with the choicest varieties of shrubbery and flowers. The farm has been surveyed by an experienced landscape gardener, with a view to the irrigation of its highest portions, its division into fields and parks, and the setting out of fruit and forest trees.

MANUAL LABOR.

The college embodies with a liberal course of study practical training in the work of the shop and the farm, its students being required to spend at least two hours daily in labor under the direction of their instructors. Although this labor is directly in the line of their studies, they are paid for it when not purely instructional. This manual labor is held to be beneficial by the financial aid it gives to the student, by instruction in methods of work, by the health derived from moderate exercise, and by the correct ideas imparted as to the dignity and importance of labor.

Military drill has been introduced, and all male students are required to participate. The State has furnished the college with thirty stand of arms for equipment. These are not sufficient for our present needs, to say nothing of future prospective growth. The drill is for twenty minutes each day, as the faculty believe a short time daily to be better than a longer time at longer intervals.

LATEST INFORMATION.

School opened September 7, 1882, with the college reorganized and a full line of work added to the course, which includes two years of drawing. The instruction in this is made supplementary to the course in the mechanic shop.

The attendance is good, there being 35 young men and 21 young ladies enrolled—total 56. The school is in a most prosperous condition; there being more students in attendance than at any previous period in the history of the college, and all are doing good, earnest, and thorough work.

The experimental work has been extended very much. One hundred varieties of wheat, 12 of barley, and several of oats were grown on the grounds this year, and the products tastefully arranged by the professor of agriculture, after which they were exhibited at the Denver Exposition and afterward at the Colorado State Fair. This exhibit was awarded the highest honors, and was conceded by all to be the finest agricultural exhibit ever seen.

CONNECTICUT.

SHEFFIELD SCIENTIFIC SCHOOL.

[Statements from the most recent reports received by this office.]

HISTORY AND OBJECTS.

The Sheffield Scientific School at New Haven, Conn., is one of the departments of Yale College, and was made, in 1863, by action of the State legislature, the beneficiary of the fund created by the national land-grant endowment for the founding of a college of agriculture and the mechanic arts. The scientific school proper was founded by the Yale College corporation in 1846 and operations begun in 1847.

A chair for instruction in agricultural chemistry was founded; then followed one in chemistry in its applications to the arts. The chemical laboratory then established was the beginning of this great scientific school.

In 1852 a section of civil engineering was provided for and a professor appointed. In 1855 a special course in metallurgy was established, and later several professors and instructors were added. At this period, the importance of the school being established, endowments were solicited. Quite a number of benefactions were made, and at last Mr. Joseph E. Sheffield, who had already bestowed $10,000, came forward with a munificent offer of a building and permanent fund. He purchased a building, refitted the same, added two wings, and gave $50,000 in addition, making the total benefaction over $100,000. Since then the school has been known by the name of its benefactor. The enlarged work began in 1859–'60.

Under the agricultural college act of 1862, Connecticut received scrip for 180,000 acres of public lands. As no part of this fund created by the sale thereof could be used for building purposes the State accepted the offer of the Sheffield Scientific School to receive the grant and fulfill its conditions. As a result of this endowment the State arranged for a board of visitors and provided for free scholarship. The faculty proceeded at once to meet the requirements of the United States statutes, by providing competent instruction in agriculture and the mechanic arts. The latter subject was embodied in the engineering section. The curriculum has been steadily strengthened and enlarged in the direction of technical science and arts as applied to industry.

Mr. Sheffield has since largely increased his endowments by enlarging the building, &c., and other important benefactions have been received.

The Sheffield school, as now organized, provides for "instruction and researches in the mathematical, physical, and natural sciences, with reference to the promotion and diffusion of science, and also to the preparation of young men for such pursuits as require especial proficiency in these departments of learning." This instruction is designed "especially for undergraduates who desire a training chiefly mathematical and scientific, in less part linguistic and literary, for higher scientific studies, or for various other occupations to which such training is suited," and also for post graduates of Yale or other colleges, and other persons qualified "for advanced or special scientific study." It is, therefore, a technical school of high character and also one for higher scientific study, investigation, and research.

ENDOWMENTS, FUNDS, AND INCOME.

The proceeds of the land grant amount to $135,000. The State pays interest on this sum at 6 per cent. to the school. The other funds of the school have in 1882 a face value of about $530,000. The total income for 1881 was $47,010, of which $17,798 were received from tuition fees. The expenses amounted to $48,796, of which sum $43,207 was expended for instruction. There are two buildings, with fixtures, costing in the aggregate somewhat over $200,000.

THE FACULTY.

The Sheffield Scientific School maintains a faculty of seventeen permanent professors, and in addition twelve instructors and assistants. The list is as follows: President; a professor of mineralogy, who is also executive officer and chairman; professor of civil engineering; of physics and astronomy (theoretical and practical); of linguistics and French; of theoretical and agricultural chemistry; of agriculture; of mathematics; of botany; of English; of political economy and history; of analytical chemistry and metallurgy; of zoölogy and geology; of comparative anatomy; of chemistry; of physiological chemistry; and of dynamical engineering. These permanent professors compose the governing board. Additional instructors and assistants are provided for in German, elocution, free-hand drawing, mathematics, French, cinematics and machine design, analytical chemistry (2), mineralogy, descriptive geometry, and projection drawing.

STUDENTS AND FEES.

There are no female students; the following is the number of students for 1882–'83: Graduates (students), 16; seniors, 47; juniors, 56; freshmen, 83; special, 5; total, 207.

The undergraduate tuition fees are $150 per annum, the graduate $100. The special student in chemistry pays $70 per annum, additional, for chemicals and use of apparatus; he is required to pay for breakage, gas, &c., the annual cost of which is about $20. A fee of $5 is charged the members of the freshmen and other classes taking laboratory practice in chemistry, mineralogy, and zoölogy; the same amount to all undergraduates for the use of the college reading room and gymnasium.

There are thirty free scholarships, twenty-seven being provided by the State and three by the governing board.

AGRICULTURAL PRACTICE.

The State of Connecticut was the first to establish an experimental station in agriculture. This was originally located in the Sheffield Scientific School and one of the professors of the institution was constituted its director. For several years the station had the free and exclusive use of the first story of the eastern wing of Sheffield Hall. The laboratory apparatus and the materials of the school have also been used when needed. But the enlargement of the chemical work of the school last year compelled the discontinuance of aid to the station, which has now ample quarters of its own in the vicinity.

The New Haven Farmers' Club has had the free use of a room for its meetings, which have been held on the first and third Fridays of the month for half the year, and on the first Friday of each month during the summer. The New Haven County Agricultural Society has had free use of rooms for its business meetings. The professors of agriculture and of agricultural chemistry have from the very first co-operated with the various agricultural societies and farmers' clubs throughout the State, and the establishment of a permanent experimental station was largely due to their influence. In various other ways, the school has, according to its opportunities, given such aid and assistance as it could to the farming and gardening interests of the State.

BUILDINGS AND APPLIANCES.

The buildings are known as Sheffield Hall and North Sheffield Hall. All instruction in mineralogy, geology, zoölogy, and comparative anatomy is now given in the Peabody Museum. These halls contain a large number of recitation and lecture rooms, a hall for public assemblies and lectures, chemical and metallurgical laboratories, an astronomical observatory, museum, a library and reading room, besides studies for some of the professors, where their private technical libraries are kept. The following is a summary statement of the collections belonging to the school: (1) laboratories and apparatus in chemistry, metallurgy, physics, and zoölogy; (2) metallurgical museum of ores, furnace products, &c.; (3) agricultural museum of soils, fertilizers, useful and injurious insects, &c.; (4) collections in zoölogy; (5) astronomical observatory, with an equatorial telescope, by Clark & Sons, of Cambridge, a meridian circle, &c.; (6) a collection of mechanical apparatus, constituting the Collier cabinet; (7) models in architecture, geometrical drawing, civil engineering, topographical engineering and mechanics, diagrams adapted to public lectures, instruments for field practice; (8) maps and charts, topographical, hydrographical, geological, &c. The herbarium of Professor Brewer and the astronomical instruments of Professor Lyman are deposited in the buildings. Professor Eaton's herbarium, near at hand, is freely accessible. Students also have access to the various laboratories and collections in natural science in the Peabody Museum. The students of the Sheffield School have also at command the libraries, school of fine arts, museums, &c., belonging to Yale College.

STUDIES AND COURSES.

The courses of instruction, occupying three years, are arranged to suit the requirements of various classes of students. The first year's work is the same for all; for the last two years, the instruction is chiefly arranged in special courses. Those most distinctly marked out are the courses in chemistry; civil engineering; dynamical (or mechanical) engineering; agriculture; studies preparatory to mining and metallurgy; natural history; biology preparatory to medical studies; and select studies preparatory to other higher studies. The arrangement of the studies is as follows:

(1) Freshman year, introductory to all courses. In addition to the usual academic studies attention is paid especially to analytical geometry and spherical trigonometry, physics, chemistry, botany, and elementary drawing.

(2) The course in chemistry for the junior year embraces recitations and lectures in theoretical chemistry, qualitative analysis and laboratory practice; mineralogy—blowpipe analysis and determination of species; French; German. The course of study for senior year embraces the following subjects: Organic chemistry; agricultural chemistry (optional); laboratory practice—volumetric and mineral analysis, assaying; zoölogy; geology; metallurgy (optional); mineralogy (optional); French.

(3) The course in civil engineering is as follows: Mathematics—elements of the theory of functions; numerical equations; differential calculus, integral calculus, rational mechanics; surveying—field operations, topographical work; descriptive geometry, drawing, warped surfaces, shadows, perspective, and topographical drawing; German; French.

The senior year embraces the following courses: Field engineering—laying out curves, location of line of railroad, with calculations of excavation and embankment, Henck's Field Book for railroad engineers; civil engineering—resistance of materials, bridges and roofs, stone-cutting, with graphical problems, building materials, stability of arches and

walls, Mahan's Civil Engineering; geology—Dana's; mineralogy—blowpipe analysis and determinative mineralogy; dynamics—principles of mechanism, steam-engine; hydraulics and hydraulic motors; drawing—graphical statics, Loomis's Astronomy with practical problems; French.

(4) The course in dynamic (or mechanical) engineering is as follows: For the junior year: Mathematics—elements of the theory of functions, numerical equations, differential calculus, integral calculus, rational mechanics; surveying—field practice; drawing—descriptive geometry; cinematics—general theory of motion and principles of mechanism, elementary combinations of pure mechanism, pulleys and belts, gearing and forms of teeth for wheels, parallel motions; German; French.

For the senior year: statics—the application of the principles of statics to rigid bodies, elasticity and strength of materials, forms of uniform strength, stability of structures, theory of the arch, construction of roof trusses, girders and iron bridges; machine drawing—bolts and nuts, riveting, journals, axles, shafts, couplings, pillow blocks, shaft hangers, pulleys, connecting rods and cranks, cross-heads, pipe connections, valves, cylinders, stuffing boxes, glands; proportioning of machine parts; designs for machines with working drawings; designing of hoisting engine, shearing and pumping engine, high speed steam engine; blowpipe analysis; shop visits and reports; hydrostatics—equilibrium and pressure of fluids, hydrometers, manometers, gauges, &c.; hydrodynamics—water-pressure engines and water wheels, construction of water reservoirs and conduits, measurement of water supply, discharge of pipes; thermodynamics—general principles of heat employed as a source of power, theory of steam engines, hot air engines, gas engines; metallurgy.

(5) The course in agriculture is as follows: For the junior year, lectures and recitations; theoretical and organic chemistry; qualitative analysis; laboratory practice; mineralogy—blowpipe analysis and determination of species; physical geography; physiology; botany; French; German. For the senior year: Agriculture—cultivation of the staple crops of the Northern States; tree planting and forestry; laws of heredity and principles of breeding; rural economy—history of agriculture and sketches of husbandry in foreign countries; systems of husbandry, agricultural and organic chemistry; geology; zoölogy; botany; microscopy; English; French.

(6) The mining course is additional, and young men desiring to become mining engineers may pursue the regular course in civil or mechanical engineering and at its close spend a fourth year in the study of metallurgical chemistry, mineralogy, &c.

(7) Lectures on military science and tactics are annually given by General Abbott and other officers of the Engineer Corps of the United States Army.

The course in drawing extends through the three years. During the first term of freshman year, the students practice free-hand drawing at the art school building. After the completion of the course in free-hand drawing, instruction is given during the second term in the elementary principles of instrumental drawing, embracing elementary projection drawing, isometric drawing, and descriptive geometry as far as warped surfaces. This course is obligatory upon all.

During the junior and senior years, instruction in drawing is obligatory only on the students in civil and mechanical engineering. In the former year the system of instruction embraces shades and shadows, tinting, perspective, and warped surfaces. By this method, all the problems in descriptive geometry are required to be worked out on the drawing-board instead of the black-board. The course extends through the entire year. In senior year students are required to apply the principles of drawing already obtained to works of construction, under the general supervision of the professors of civil and of dynamic engineering.

(8) In addition to these courses and studies, which may properly be esteemed as falling within a comprehensive conception of the purposes of Congress in creating an endowment for colleges of agriculture and the mechanic arts, the Sheffield Scientific School has courses of highest scientific studies, as follows:

(9) In natural history, either geology, mineralogy, zoölogy, or botany may be made the principal study, some attention in each case being directed to the other three branches of natural history. For the junior year, the course embraces chemistry, qualitative analysis, laboratory practice, mineralogy, blowpipe analysis, and determinative mineralogy; botany—Gray's manual, laboratory practice; zoölogy—laboratory practice, recitations, excursions (land and marine); botany—laboratory practice, excursions; physiology; physical geography; German; French.

For the senior year: geology—Dana's, excursions; zöology—laboratory practice, lectures, recitations, excursions; botany—herbarium studies, comparative cryptogamous orders, botanical literature; essays in descriptive botany, excursions; anatomy of vertebrates—Huxley's; zöology—laboratory practice, recitations, lectures; meteorology; French. Besides the regular courses of recitations and lectures on structural and systematic zoölogy and botany and on special subjects, students are taught to prepare, arrange, and identify

collections, to make dissections, to pursue original investigations, and to describe genera and species in the language of science. For these purposes large collections in zoölogy and paleontology belonging to the college are available, as are also the private botanical collections of Professor Eaton.

(10) The course in biology, preparatory to medical studies, embraces two years and covers theoretical and organic chemistry, mineralogy, physiology, toxicology, physiological chemistry, botany, zoölogy, geology, comparative anatomy and histology; the laws of heredity and breeding, with laboratory practice as needed; also German and French.

(11) A course of select studies preparatory to other higher studies, is also provided and embraces mineralogy, English history and literature, English history, physical geography, botany, political economy, geology, zoölogy, linguistics, meteorology, German, and French.

DEGREES.

The degrees which are conferred are bachelor of philosophy, civil engineer, dynamical engineer, and doctor of philosophy. The degree of bachelor of philosophy is conferred upon those who complete any of the three years' courses of study, passing all the examinations in a satisfactory manner and presenting a graduation thesis. Those upon whom this degree has been conferred may obtain the engineering degrees at the end of two academical years by pursuing a course of higher study and obtaining professional training through special investigations or actual practice. The course of study for the degree of civil engineer comprises higher calculus, higher geometry, theory of numerical operations, analytical and applied mechanics, practical astronomy, and a course of construction and design. The course of study for the degree of dynamical engineer is slightly varied from that just given, astronomy being omitted, and other studies so pursued as to bring mechanics and mechanical engineering into prominence. The degree of doctor of philosophy is conferred upon those who, having already taken a bachelor's degree, engage in assiduous and successful study in the department of philosophy and the arts for not less than two years.

DELAWARE.

DELAWARE COLLEGE.

[Statements from the most recent reports received by this office.]

This college, located at Newark, Del., has been made the beneficiary by the State of the fund arising from the national land grant in behalf of agricultural colleges.

The catalogue for 1879–'80 states that "It is the design of the college to give to young men of proper age and acquirements such a course of instruction, directly pertaining to agriculture, as will enable them to conduct the operations of a farm both intelligently and profitably, and at the same time, by the introduction of such other studies as constitute a substantial education, to secure thorough mental discipline."

ENDOWMENT AND INCOME.

The proceeds of the land scrip sales form the permanent fund of this institution; it amounts to $83,000; the annual income therefrom is $4,980; income from tuition fees (1881), $500; total income, $5,520. The grounds, buildings, and appliances are valued at $75,000.

Faculty.—The number of professors is five, and includes the president, who is also professor of mental, moral, and political science, and the professors of agriculture, physics, and civil engineering; of chemistry, mineralogy, and natural history; of mathematics and modern languages; and of ancient languages and classical literature. There are also several lecturers.

Students.—The return for 1880–'81 reports 54 students, 11 of whom were young ladies. There are 30 State scholarships in the gift of the members of the State assembly. The fees are $5 for matriculation and $60 a year for tuition.

Studies.—The agricultural and scientific department embraces the following: In the freshman year, besides usual collegiate studies, anatomy, physiology, the laws of health, modern and constitutional history, and practical mathematics are taught.

The sophomore class study, in addition to English, Latin, and literature, agriculture, inorganic chemistry, zoölogy, higher algebra, geometry, botany, and political economy.

The course of the junior class includes organic chemistry, mineralogy, French or German, trigonometry, mensuration, agriculture, surveying, and navigation.

The senior class, in addition, study astronomy, physics, civil engineering, geology, differential calculus, elements of law, international law, and also use the laboratory.

There is a special course given in chemistry. The recitations and lectures in agriculture embrace the following subjects: the formation of soils, their chemical and physical qualities, their suitability for different kinds of crops, and the industrial and commercial effects of the varied distribution of soils in the United States; the constituents and chemical agencies of the atmosphere and of the water, and the composition of manures; farm implements, principles of construction and use; the botany of agriculture, classification of plants, a knowledge of the crops cultivated for food and for other special purposes; the anatomy of domestic animals; rotation of crops, improvement of soils by manuring and draining; methods of conducting experiments; and a consideration of the history of agriculture, and the State and national policy in relation to the development of agricultural interests.

Women are admitted and a special literary course is arranged for them. As to special appliances, beyond small library, laboratory, and usual philosophical apparatus, no information is given.

Experimental and practical work.—The college does not own a farm, but students are instructed on that owned and worked by the professor of agriculature, who is also under a State law regulating the manufacture and sale of fertilizers ex-officio State chemist; "it is his duty to inspect by analyses samples of all the fertilizers offered for sale in the State. As a consequence of the performance of this duty, many worthless articles have been driven from the market, and the fertilizers remaining have been greatly improved in quality. From the analyses made by the State chemist, farmers have learned the necessary constituents of plant food, and, profiting by this knowledge, have been enabled to make their purchases to the best advantage.

Hon. W. H. Ruffner, of Virginia, in narrating a recent visit to Delaware College, for the State Agricultural College of Virginia, says: "The department of agriculture in the Delaware College is conducted by means of expositions in the class room and visits to the farm of the professor of agriculture, who carries on a system of mixed husbandry on private account, and is himself a skilled and laboring farmer, as well as a man of scientific education. He keeps a liberal supply of tools and takes his class not only to witness the various operations of farming, fruit growing, and trucking, but to handle the tools and implements. Nothing very systematic, however, is required. The professor also takes his class to visit the machine and implement shops, of which there are many in Newark."

GEORGIA.

THE STATE UNIVERSITY AND ITS BRANCHES.

[Statements from catalogues and letter.]

HISTORY OF THE DISPOSITION OF THE GRANT.

The entire proceeds of the sale of agricultural college scrip ($242,202.17) were given to the University of Georgia in 1872.

A college of agriculture and the mechanic arts was then established as a department of the university. In the same year the United States mint building at Dahlonega was donated to the university by the general government, and a department of the university opened there under the name of the North Georgia Agricultural College. Two thousand dollars are annually appropriated to it from the income of the agricultural fund of the university. In 1878 branch institutions were added, one of them at Cuthbert, called the Southwest Georgia Agricultural College, and the other at Thomasville, called the South Georgia Agricultural College. Each college receives $2,000 a year from the land-grant fund.

In 1879 the Middle Georgia Military and Agricultural College, at Milledgeville, having the old State buildings for its use, was made a part of the system. It also receives $2,000 per annum.

The State legislature pays to the industrial department of Atlanta University $8,000 per annum, as in lieu of all claims of colored citizens upon the land-grant funds. The total disbursed under this head is as follows: Total income from fund created by sale of the land-grant scrip given by the United States to the State of Georgia for the use of a college of agriculture and mechanic arts, as per secretary's report 1880, $17,914.14; appropriated annually by legislature for use of colored students to the Atlanta University, $8,000; total income for industrial and technical education, $25,914.14. This is disbursed as follows: State College of Agriculture and Mechanic Arts, at Athens, $9,914.14; North Georgia Branch College, at Dahlonega, $2,000; Middle Georgia Branch College, at Milledgeville, $2,000; South Georgia Branch College, at Thomasville, $2,000; Southwest Georgia Branch College, at Cuthbert, $2,000; Atlanta University, $8,000.

GEORGIA STATE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS.

The leading object of the department of the University of Georgia known as the State College of Agriculture and the Mechanic Arts is to teach scientific agriculture and afford young men opportunities for instruction in practical departments, such as engineering, analytical chemistry, and mechanics.

The annual income consists of the remainder of the income of the land grant after deducting the sums devoted to other branches of the university, or about $8,000.

The faculty consists of chancellor of the university and seven professors, teaching the following subjects: English literature, modern languages, mathematics (pure and applied), chemistry, geology, and mineralogy, physics, astronomy, engineering, and military tactics, and agriculture and horticulture.

The number of students in 1882 was 39. The number taking agriculture as a study was 29. Tuition, in July, 1881, was made free. But every student pays $10 matriculation and $5 library fee—$15 annually.

The number of graduates from the organization of the college in 1872 until and including 1880 was 53, of whom 25 were civil engineers, 11 bachelors of engineering, 11 bachelors of chemical science, and 6 bachelors of agriculture. The number of bachelors of agriculture does not fairly represent the number of students who have attended the college for the purpose of preparing themselves for farming as a profession. Many of them have taken degrees in engineering or chemical science.

APPLIANCES AND APPARATUS.

In addition to instruction by recitation and lectures in the class room students in agriculture visit frequently the experimental farm connected with the university, which is under the direct supervision and management of the professor of agriculture, and there receive practical instruction.

The new laboratory building for the use of the college of agriculture and mechanic arts, now constructed, is 100 by 50 feet, three stories with basement. The entire first floor and basement are appropriated to the department of chemistry, containing analytical laboratories, balance rooms, an assay room, a room for microscopic and spectroscopic work, an industrial museum, store room, engine room, workshop, printing office, &c. The second floor contains a lecture room and museum for the department of agriculture, and apparatus room, working room, and lecture room for department of natural philosophy. The third floor contains a model room, lecture room for students in engineering, and drawing hall.

Under an appropriation made by the State legislature of $15,000 this building has been equipped with the modern apparatus requisite for chemical and physical laboratories and models, &c., required in the department of engineering.

The university chemical laboratories are located therein; they comprise rooms for elementary work, for qualitative, quantitative, and volumetric analysis. These are connected with convenient balance rooms, an assay room, evaporating chambers, &c., and are completely fitted with all necessary appliances for chemical work, and furnished with gas, water, rapid filtration apparatus, &c.

The appliances in the department of physics are worth about $10,000. Three-fourths of this value represent new and modern apparatus recently bought. All the apparatus is in excellent condition, and is constantly kept in perfect working order. The selection has been made carefully, every piece being bought from that maker with whom its manufacture is a specialty. The apparatus illustrating optics was purchased of Duboseq; that illustrating acoustics, from Koenig; for heat, from Salleron; for electrical tests, from Eiliott—all European makers. The general apparatus was procured of Ritchie of Boston and Queen of Philadelphia. Students pursuing the courses for the degrees of B. S. and B. E., and others who desire to do so, take a special course in practical physics in addition to the general course. In it students perform under the professor's direction the experiments, and explain them as they proceed or submit their results for criticism. They are thus taught to handle apparatus, to improvise and construct apparatus of their own, to make their own verifications of the truth of principles, and to perform such tests as belong to physical work. The department occupies a well arranged lecture hall, an apparatus room, a laboratory, and a workshop for the construction and repair of apparatus.

The department of engineering, in addition to full sets of surveying instruments, possesses a very fine collection of working models of engineering structures and of machinery, by the aid of which the actual construction of bridges, roofs, &c., can be thoroughly illustrated. Amongst them are found working models of high and low pressure steam engines; models of steam boilers; of roofs and bridges; of water wheels; of railway tracks; of machinery; of the orders of architecture, &c.

To the department has lately been added a fine machine for testing the strength of materials, made by Riehle of Philadelphia; this machine works up to 41,000 pounds, and materials can be tested for tensile, crushing, or transverse strength. There are also a large number of plates and drawings illustrating engineering works.

A large hall, 50 by 84 feet, well lighted, is used by the students in drawing.

The legislature has granted to the university 200 stand of arms. All students, both in the State college and academic departments of the university, unless exempted by the faculty, are required to take part in the regular drills; these are conducted on three afternoons of each week of the session, when the weather is favorable, between the hours of half past four and half past five.

STUDIES AND DEGREES.

Every student who enters the college is required to take one of the prescribed courses. He can elect either the course of agriculture, or of engineering, or of applied chemistry, or a partial course. He can also add to the studies of the prescribed course those of the schools of the university for which he may be prepared, provided that his election does not interfere with the daily schedule of recitations and lectures.

The agricultural course is as follows:

In the freshman class, besides English studies, algebra, geometry, linear drawing, and botany are pursued.

In the sophomore class book-keeping, geometrical drawing, elements of mechanics, trigonometry, mensuration, and surveying, with field and practical work, zoölogy, botany, and agriculture are studied.

In the junior class the following studies are pursued: Chemistry; agricultural chemistry, with six hours per week laboratory practice; natural philosophy; mechanics of solids, liquids, and gases; acoustics; heat; natural history; surveying and drawing; agriculture, its principles, its methods, its products, methods of propagating plants, general nursery management, practical illustration on experimental farm; French or German; English literature.

The senior class has the following course: Industrial chemistry; agricultural chemistry, including the chemical composition of the plant, the laws regulating its growth, the physical and chemical properties of the soil, the composition and manufacture of fertilizers, laboratory practice in agricultural analysis of six hours per week; natural philosophy; light; magnetism; electricity; meteorology; descriptive anatomy; agriculture, implements, crops, farm management, stock breeding, economy of labor, preparation of manures and composts, taught practically on the experimental farm; geology and mineralogy; rural engineering and building construction; English literature.

The entire course entitles graduates to the degree of bachelor of agriculture.

It is the design of the school of agriculture to give a thorough knowledge of theoretical and practical farming, so that the agriculturist may do his work carefully and skillfully. With this view the students are instructed by text books and professors' lectures in the following subjects:

Classification of soils, their mineral ingredients, chemical composition, and physical properties; how these properties may be changed and improved; the best mode and implements of tillage; the advantages of subsoiling and drainage, and how these may be best performed, and the various kinds and properties of manures.

Plants, botanically, economically, and geographically considered; those adapted to the food of man, how and where produced, their properties and value, which can be produced best at home, and which purchased from abroad.

The design, use, location, arrangement, kind of soil, culture, and implements of the vegetable garden and orchard; pruning, transplanting, and propagation of fruit, ornamental, and forest trees.

The anatomy and physiology of the domestic animals, their breeding, management, and adaptation to farm economy.

Insects, their classification, history, and habits; which are noxious and should be destroyed, and which beneficial and should be preserved.

Farm buildings and farm machinery.

Landscape gardening, laying out gardens and lawns and their ornamentation, and the culture and propagation of flowers and shrubs.

Students in agriculture meet with the classes in engineering in some studies; they become draughtsmen, and are enabled to make necessary plans. Attention is particularly turned to the construction of farm buildings. They also study surveying and join in all field exercises.

Special instruction is given on the drainage of land, and the manner of laying the lines of drainage is thoroughly illustrated by practice in the field.

Instruction is also given in strength of materials; in framing and building; in the construction of roads.

The engineering course embraces for the freshman and sophomore classes the same studies as those of the agricultural course. The studies pursued by the juniors and seniors lead to the degree of bachelor of engineering, and embrace the following subjects: Analytical and descriptive geometry; geometrical, topographical, isometrical engineering, and plan drawing; tinting, lettering, shades and shadows, and perspective; surveying with chain, compass, and transit; leveling; natural philosophy; mechanics of solids, liquids, and gases; acoustics; light; heat; magnetism; electricity; meteorology; elements of astronomy; French or German; differential and integral calculus; mechanics of engineering; chemistry; mineralogy and geology; laboratory practice; mechanics, theoretical; astronomy, spherical and descriptive; analysis of engineering constructions; thesis.

A special course of one year for the degree of civil engineer includes the following subjects: Weisbach's or Mosely's Mechanics of Engineering; Stoney on Strains; Warren's Machine Construction and Draughting; chemical laboratory work; French or German; thesis.

The department of engineering has also organized a partial course in "building and architecture;" it includes the studies of the first, second, and third years in engineering, omitting a part of the higher mathematics, and instead thereof giving attention to architectural drawing, structures of wood, stone, and iron, foundations, walls, arches, trusses, roofs, &c.; the application of descriptive geometry to masonry and carpentry; strength of materials; ventilation, warming, acoustics; building materials, woods, stones, mortars, cements, paints, &c.

Upon the satisfactory completion of this course a certificate will be given stating the time spent at the college and the progress made.

The school of engineering is organized for the benefit of the following classes of students, namely: (1) Those who intend to make engineering a profession, the course of instruction enabling the student to acquire such a practical knowledge of the science as to be qualified for entering, upon graduation, upon the duties of the profession; (2) those who desire to study applied mathematics, to complete the scientific course.

The students in the regular course of agriculture not able to complete one of the regular courses confine themselves to the study of such subjects as they may elect.

The mode of instruction is partly by means of text books, but principally by lectures. Throughout the course the application of the theory is enforced by requiring the solution of practical problems, by exercises in the field, and by the construction of original drawings, with necessary bills of materials and specifications.

In the course of surveying each student has abundant opportunity to manage and use the instruments himself. Every operation is illustrated by actual field work.

The course of drawing includes all the principles required in the practice of the professional engineer and architect. Each student of the State college is employed in drawing during a part of the course from one to two hours each day. During the first year all are required to take linear drawing, and the work done is intended to be auxiliary to the study of geometry.

The full course includes orthographic and isometrical projections; development of surfaces; practical perspective; linear, free-hand, and object drawing; building and architectural drawing; masonry drawing; drawing for carpenters; mechanical drawing, including drawing from rough sketches, drawing and shading from solid objects, drawing of machinery.

The course in chemistry leads to the degree of bachelor of chemistry and embraces, for junior and senior classes, the following studies:

For the junior class—general chemistry; laboratory practice, including chemical manipulations; blow-pipe analysis and qualitative analysis; physics; mechanics of solids, liquids, and gases; acoustics, light, heat; English and English literature; French; German.

For the senior class—industrial chemistry, including mining, metallurgic processes for the extraction of the useful metals, the manufacture of important commercial chemicals, acids, salts, fertilizers, &c.; the manufacture of glass and porcelain; agricultural chemistry, the composition and use of crude and manipulated fertilizers, &c.; the manufacture of cane and beet sugar, of alcohol; wine, beer, vinegar, &c.; bleaching, dyeing, calico printing, and tanning; gunpowder and other explosives; soap and candles; gas and illuminating oils; printing, photography, &c.; laboratory practice; quantitative analysis; gravimetric and volumetric analysis of soils, fertilizers, blood, urine, metals, ores, &c. (the student will be employed in this laboratory work for five hours each day during six days of the week); mineralogy; geology; physics, magnetism, electricity, meteorology; astronomy; French; German.

Besides lectures and recitations, a certain amount of time to be devoted to practical work is required of each class, but facilities are offered each student to increase the amount if desired.

A preliminary course of instruction is given in manipulation, and constant practice is required, that students may familiarize themselves with such portions of the laboratory work as require mechanical skill, with glass blowing, handling and care of apparatus, use of blow-pipe, &c.

A course of blow-pipe analysis is next given; then a thorough course in qualitative chemical analysis is pursued, until the student is competent to determine the chemical constituents of an unknown substance presented to him.

The remainder of the course is devoted to quantitative analysis, gravimetric and volumetric, the quantitative determination of the chemical constituents of a substance the composition of which has been previously determined by qualitative analysis. After passing the regular course to the necessary extent, the students will be allowed considerable latitude in the choice of substances for examination, whether of soils or fertilizers, in connection with the study of scientific agriculture; of blood, urine, &c., by the medical student; of metals and ores, by those interested in mining, mineralogy, and metallurgy.

NORTH GEORGIA AGRICULTURAL COLLEGE.

This college, opened January, 1873, is located in Northern Georgia, at Dahlonega. Its building was destroyed by fire in December, 1878, but has been rebuilt on the old foundations. It has a front of 122 feet, with an extension in the rear of 87 feet, and is three stories high. It contains a chapel room, society halls, fourteen recitation rooms, library room, and chemical laboratory.

No special age or preparation is necessary for admission to the college. While it is desirable that all pupils should enter at the beginning of the term, yet they are received at any time, and such is the scope of instruction that a grade can at all times be found for those entering late. Tuition is free, but a matriculation fee of $5 a term or $10 a year is required of each student.

The session commences first Monday in September, and is continuous for two terms. Spring term commences February 1 and ends June 15. Military drill is compulsory, and students are required, when on drill, to wear uniforms.

The military department is under the management of a United States officer, especially detailed by the Secretary of War as commandant of cadets at this institution.

The educational intelligence afforded by this institution has especially in view the preparation of the pupil (1) for the business and for the enjoyment of practical home and farm life, (2) for the higher classes in the University of Georgia, and (3) for the profession of teaching and as a passport for the same. Certificates of proficiency in the studies of the several departments and of qualifications to teach will be granted by the trustees to students showing diligence, aptitude, and progress in their education.

The faculty, by express authority of the legislature, can grant licenses to the students of this institution to teach in the State schools without examinations. It consists of five professors, two adjunct professors, and one assistant. Number of students for the session of 1881: males and females, 177. Of this aggregate there are in the college classes 48, viz: seniors, 6; juniors, 11; sophomores, 13; freshmen, 18. The balance, 129, are in the preparatory and primary classes.

MIDDLE GEORGIA MILITARY AND AGRICULTURAL COLLEGE.

This college, opened January, 1880, is located at Milledgeville, Baldwin County, Georgia.

The old State capitol buildings and grounds, donated to the trustees of the State University for the purpose of establishing this college, furnish ample accommodations.

The faculty consists of 5 professors and 5 teachers. Number of students (1882), 355; 37 are in college grade. Under college grade there are 318, viz: 151 boys and 167 girls. Military exercises form a part of the instruction, and the boys are required to wear a uniform.

The college has recently come into possession of a library consisting of about 3,000 volumes.

SOUTHWEST GEORGIA AGRICULTURAL COLLEGE.

This college, opened in September, 1879, is located at Cuthbert, Randolph County, Georgia. The college building is spacious and well arranged, with capacity to accommodate from two hundred to two hundred and fifty students.

The real estate belonging to the college embraces an area of 30 acres. The situation is beautiful, pleasant, and well adapted to such an enterprise.

No charge is made for tuition, but an incidental fee of $5 per session is required of every student able to pay, making $10 for the year.

The faculty consists of 3 professors and 1 assistant. The number of students for the

present session (all males) is 155, of whom 25 are in college grade, viz: 7 in the sophomore class and 18 in the freshman. The remainder, 130, are under college grade.

Military exercises form a part of the scheme of instruction, and the students are required to wear a uniform.

SOUTH GEORGIA AGRICULTURAL COLLEGE.

This college, opened in September, 1879, is located at Thomasville, Thomas County, Georgia. The buildings, all brick, are three in number, capable of accommodating about one hundred and seventy-five or two hundred students. The main building has recitation rooms below and four rooms above used for sleeping rooms for students. The recitation rooms are all comfortably furnished.

Tuition is free, but a matriculation fee of $5 per term is required, making $10 a year.

Session begins first Wednesday in September and continues forty weeks.

The faculty consists of 5 professors. Number of students (all males) was, in 1882, 185, of whom 14 are in college grade. The remainder, 171, are under college grade.

All students are required to drill and to wear uniform.

ATLANTA UNIVERSITY.

Atlanta University was chartered in 1867 and organized in 1869. It is designed to afford the colored people opportunities for obtaining such education as shall be most profitable to them. It has three courses of study, the college, college preparatory, and the normal. A grammar school is also connected with the university.

In the year 1880–'81 the number of students in the college course was 17; in the college preparatory course, 14; in the normal course, 83; in the grammar school, 227. Of the 341 students, 158 were boys, 183 girls; 215 were boarders and 126 day pupils.

The faculty consists of the president, 3 professors, and 11 instructors and teachers. The graduates previous to 1881 in the college course (A. B.) numbered 22; in the normal course, 49.

The expenses for tuition are $2 a month in the college course and $1 per month in the other courses.

The board is estimated at $8 per month, and all pupils are required to work for the institution at least one hour a day.

The university has only $5,300 permanent fund, a little physical apparatus, and a library of about 500 volumes. The $8,000 annually given by the State is its chief income. There are three commodious buildings.

ILLINOIS.

ILLINOIS INDUSTRIAL UNIVERSITY.

[From report by the regent, supplemented by material from catalogues.]

The leading objects of the Illinois Industrial University are those expressed by the terms of the act of Congress of 1862, under which the State received the endowment that supports the teaching force of the university.

ENDOWMENT AND FUNDS.

The State of Illinois received from the United States, in accordance with the provisions of the act of 1862, scrip for 480,000 acres of land. Scrip for 454,460 acres was sold, yielding $319,178.17, and the proceeds were invested in approved State and county securities in the State of Illinois. The remaining scrip, 25,440 acres, was located in Minnesota and Nebraska upon lands which are yet part of the property of the university, but unproductive. There is no other endowment.

The real estate of the university situate in Urbana, its farms and public grounds, with the buildings thereon, and its other property in machinery, apparatus, library, stock, &c., have been obtained partly from donations of the cities of Urbana and Champaign and their residents, and partly from appropriations made in successive sessions by the State. The total value of such property may be estimated (1882) at $400,000 to $450,000.

Receipts and expenditures for the years ending at the dates given.

	September 30, 1880.	September 30, 1881.
RECEIPTS.		
Balance from last year:		
State	$10,618 66	$5,582 91
Current	7,298 93	7,168 23
Interest on endowment	21,398 40	20,660 00
From State appropriations	8,695 50	26,610 37
From fees and room rent	10,619 21	9,908 67
Gross receipts from departments of labor	15,053 34	16,100 41
Illinois Central Railroad freight donation	.....	2,199 60
Miscellaneous	943 24	981 98
Total	74,627 28	89,212 17
EXPENDITURES.		
On account of salaries	28,184 22	28,392 54
On account of State appropriations	13,842 88	15,712 91
On account of departments of labor	12,595 62	16,188 67
Miscellaneous	7,253 42	7,763 54
Total	61,876 14	68,057 66
Balance:		
State	5,582 91	16,451 85
Current	7,168 23	4,702 66
	74,627 28	89,212 17

ORGANIZATION.

The organization of the university provides instruction in these colleges and schools: The college of agriculture, the college of engineering, school of mechanical engineering, school of civil and mining engineering, school of architecture, the college of natural science, school of natural history, school of chemistry, the college of literature and science, school of English and modern languages, school of ancient languages. Additional schools: The school of military science, school of art and design.

In each of the schools enumerated above instruction has been given continuously throughout the year. The question as to which of them are "leading" will be best answered by the list of professorships, and by describing the facilities, including buildings, farms, workshops, laboratories, apparatus, &c., furnished and in use as the equipment for instruction.

FACULTY.

The faculty consists of the regent, who is professor of mechanical engineering and physics; professor of botany and horticulture (vice-president), professors of mathematics, modern languages, geology and zoölogy, English language and literature, architecture, history and ancient languages, chemistry, agriculture, veterinary science, industrial art and designing, military science and tactics, civil engineering, and agricultural chemistry; assistants in mechanical engineering, English and ancient languages, and laboratory work, instructors in right-line drawing, elocution, mathematics and botany, and natural science; a teacher of vocal and instrumental music, and foremen of carpenter and machine shops.

STUDENTS.

Three hundred and fifty-two students were in attendance in 1881–'82, classified as follows: Resident graduates, 9; seniors, 35; juniors, 49; sophomores, 91; freshmen, 87; preparatory, 71; special, 10. The course in agriculture was pursued by 21 students; mechanical engineering, by 41; civil engineering, 41; mining engineering, 3; architecture, 14; chemistry, 42; natural history, 14; art and design, 4; English and modern languages, 105; ancient languages, 16; elective, 14; miscellaneous, 35. There were 76 ladies among the number, one of whom studied chemistry; 1, art and design; 4, elective courses; 7, courses not specified; 9, natural history; 50, English and modern languages; and 4, ancient languages.

Tuition is free in all the university classes. A matriculation fee of $10 entitles the student to membership in the university until he has completed his studies. Fees for

incidental expenses amount to $22.50 annually. Students are charged for material used or apparatus broken in the laboratories, but not for the use and ordinary wear of instruments.

The legislature of Illinois in the act founding the university provided that no degrees should be conferred nor diplomas awarded, but that certificates might be given which should set forth the studies pursued and the proficiency attained therein during the residence of students at the university. A full certificate, deemed equivalent to evidence of graduation, was evidence of satisfactory attainment in thirty-six university studies covering one term each. In 1877 the legislature gave authority to confer degrees, and pursuant to that authority degrees of bachelor of science, bachelor of letters, bachelor of arts, master of science, master of letters, master of arts, civil engineer, and mechanical engineer have been conferred.

The total number of graduates to 1882 holding full four years' certificates is, men 179, women 34, total 213. Graduates from 1877 to 1881: bachelor of arts, men 4, women 2, total 6; bachelor of letters, men 33, women 17, total 50; bachelor of science, men 71, women 11, total 82. Total number of graduates 347, men 280, women 67.

A list of the graduates with their occupations and residences is given in the catalogue for 1881–'82. According to it, 52 are engaged in teaching, 37 in farming, 33 in law, 27 in engineering, 18 as clerks and agents, 15 in household duties, 14 in medicine, 12 are merchants, and 11 architects or draughtsmen, and the remainder are distributed among a score of different occupations.

OUTLINE OF PLAN OF INSTRUCTION.

Each school has a well-defined course of study, peculiar to itself in certain technical branches. The full time for each of the courses of study is four years; but students take a longer time if necessary, or if competent they may complete a course in less time. A student may, under certain conditions, arrange a course of study for himself, and when he shall have completed thirty-six terms of university subjects he is entitled to a full certificate setting forth the facts.

THE COLLEGE OF AGRICULTURE.

The object of the College of Agriculture is to lead the student toward a thorough understanding of all that man can know about soils and seeds, plants and animals, and the influences of light, heat, and moisture on his fields, his crops, and his stock, so that he may both understand the reason of processes he uses and may intelligently work for the improvement of those processes. Theory and practice are united in the method of instruction. The technical studies are taught mainly by lectures, with careful reading of standard agricultural books and periodicals and frequent discussions, oral and written, by students, of the principles taught. These are also illustrated by demonstrations and observations in the fields, stables, orchards, gardens, and plant-houses.

The requirements for admission to the agricultural course are that the candidate be at least fifteen years of age and pass satisfactory examinations in common school branches and the studies of the preliminary year, which are algebra, geometry, natural philosophy, botany, physiology, and studies in English. For admission to a "farmer's" course of one year examination in common school branches only is required.

There are two courses of study, one covering four years, the other one year. The former is the regular course leading to the degree of B. S. Its studies are as follows:

First year: elements of agriculture and horticulture, vegetable physiology, chemistry, trigonometry, rhetoric, British authors or free-hand drawing, and shop practice.

Second year: agricultural chemistry, economic entomology, zoölogy, botany, and German.

Third year: agricultural engineering and architecture, animal anatomy and physiology, animal husbandry, veterinary science, landscape gardening, geology or ancient history, and physics or mediæval and modern history.

Fourth year: meteorology and physical geography, history of agriculture and rural law, rural economy, political economy, constitutional history, mental science, history of civilization, and laboratory work.

Special horticultural branches may be substituted for agricultural or veterinary studies by those so desiring. The shorter course is called the farmer's course. Its studies are taught in the following order: First term: elements of agriculture, agricultural engineering and architecture, animal anatomy and physiology, shop practice. Second term: animal husbandry, rural economy, veterinary science. Third term: history of agriculture and rural law, veterinary science, practical entomology or landscape gardening.

The studies of the second or winter term are arranged so as to be profitably studied by those who can be in attendance only during that term.

As will be seen by the courses given above, the agricultural studies are included under the heads elements of agriculture, agricultural engineering and architecture, which includes drainage, irrigation, water supply, fencing, building, and machinery; animal husbandry, including breeds and breeding; rural economy, history of agriculture, and rural law. The special studies in horticulture are (1) elements of horticulture, in which are briefly discussed nursery work, orcharding, ornamental trees and shrubs, flower gardens, vegetable gardens and their accessory hot beds and houses, vineyards, and small fruits. Instruction and practice is given in grafting, budding, and propagation. (2) landscape gardening, in which the principles and history of the art, the laying out of grounds, the construction of buildings, the use of water, and many other similar things are taught. Practice in designing grounds is given. (3) floriculture, or the kinds, propagation, growth, and care of flowering and other ornamental plants. (4) pomology and forestry, which are each accompanied with practical work. (5) plant-houses and management. This study includes gardening and landscape architecture, and the construction, heating, ventilation, and general management of plant-houses so as to secure the best growth. Practice is afforded in the plant-houses of the university.

The class-room work consists of lectures and architectural designing and drawing.

Veterinary science is taught during the third year. In the first term the anatomy and physiology of the domestic animals is taught by lectures, demonstrations, and dissections. Post-mortems of healthy and diseased animals are made, so that the student may become practically acquainted with the tissues in health and disease. The first six weeks of the second term are devoted to the study of medicines, their actions and uses; the remainder of the term, to lectures on the principles and practice of veterinary science. During the third term, practical instruction is given in clinical work, as cases present themselves at the veterinary infirmary, where animals are treated or operated upon, free of charge, for the instruction of students. Lectures are also given on veterinary sanitary science and the principles and practice of veterinary surgery.

The apparatus and appliances which are used in the aid of instruction are described a few pages further on.

COLLEGE OF ENGINEERING.

The three schools embraced by this college are designed to thoroughly train students of engineering and architecture. The instruction in the school of mechanical engineering, while severely scientific, is thoroughly practical.

The mechanical laboratory is in use at every stage. Principles are imparted by lectures, text-books, and illustrations. Test experiments in machines and motors are tried. Practice is acquired by the production of elementary forms and the execution of projects. Designing is a necessary part of every term's work, and accompanies all studies. Shop practice is carefully arranged in order to fully familiarize the student with tools, machines, and the mode of their production. This practice represents four branches: Pattern-making, blacksmithing, bench-work for iron, and machine tool work for iron. The course fits the student for the advanced shop practice in designing and constructing complete machines, which is undertaken after finishing the elementary work of the first year.

The students in the course leading to the degree of bachelor of science in the school of mechanical engineering are, in the first year, trigonometry, analytical geometry, calculus, descriptive geometry and lettering, freehand and projection drawing, French or German, and shop practice. Second year: The advanced study of algebra, analytical geometry and calculus, the designing and construction of machines, astronomy, and French or German. Third year: Analytical mechanics, advanced descriptive geometry, physics, chemistry, with laboratory practice, mechanism, laboratory work, and modern history. Fourth year: Resistance of materials, hydraulics, prime movers, mill-work, construction drawing, designing and laboratory work, geology, mental science, constitutional history, political economy, and thesis.

The student is trained in the school of civil engineering by a combination of theoretical instruction with practical work. In the first three years the student is trained to undertake engineering operations, while the fourth year is designed to fit him to plan and direct such works as making geodetic surveys, building arches, trestle bridges, and all supporting frames.

In the second year the class makes a complete topographical survey of a locality with preparation for a railroad survey, executed at a later date. A project in geodesy is executed by the seniors. Great attention is paid to surveying in its highest branches. Astronomical studies, with use of the observatory, are encouraged.

The courses of the first and second years are the same as in the mechanical school, with the exception that shop practice is omitted, and in the second year the designing and construction of machines are superseded by land and topographical surveying, with theory of instruments and topographical drawing. The third year includes advanced descriptive

geometry, chemistry, and laboratory practice, railroad engineering, analytical mechanics, astronomy, and physics.

The fourth year embraces resistance of materials and hydraulics, geodesy and practical astronomy, geology, bridges and bridge construction, stone work, constitutional history, political economy, mental science, and thesis. Students in mining engineering take a course in metallurgy in place of geodesy and practical astronomy, bridges and bridge construction. There are well-furnished cabinets of geological and mineralogical specimens, and the chemical laboratory embraces assaying and metallurgical departments, with stamp mill, furnaces, &c., for practical instruction.

The school of architecture prepares students for that profession. Among the subjects in which practical instruction is given are office work and shop practice in such work as constructing joints in carpentry and joinery, cabinet-making, turning, &c.; also modeling in clay. The courses in mathematics, mechanics, physics, &c., are nearly identical with those in the schools of engineering. The technical studies embrace drawing from casts, modeling in clays, elements of construction; wood, stone, brick, and iron construction; tinners' work, slating, plastering, painting, and plumbing, architectural drawing and designing; history and esthetics of architecture, estimates, agreements, and specifications, heating and ventilation, graphical statics. The shop practice and the method of instruction are similar to those of the Russian system. The students' work from scale drawings occupies three terms; in the first, carpentry and joinery are taught; in the second, turning and cabinet-making; in the third, metal and stone work, pattern-making, &c. There is a large shop well arranged and fitted up for the carpenter and cabinet work. A course known as the builders' is provided for those who can take only a single year.

COLLEGE OF NATURAL SCIENCE.

This is divided into schools of chemistry and of natural history. A school of domestic science was formerly included. It has been abandoned for the present.

The school of chemistry is designed to equip students for work in the related arts, as well as for the field of original research and the practical business of pharmacy and chemistry. There are four distinct courses: chemical, pharmaceutical, agricultural, and metallurgical, each of which has a special laboratory work arranged for it.

The studies required to be completed by candidates for the degree of bachelor of science in the school of chemistry are, in the first year, chemistry and laboratory practice, free-hand drawing, trigonometry, analytical geometry, literature and rhetoric, or French; in the second year, agricultural chemistry, laboratory practice, physiology, or botany, microscopy, zoölogy, and German; in the third year, laboratory practice, mineralogy, physics, and German; in the fourth year, laboratory work, meteorology, and physical geography, geology, logic, mental science, constitutional history, and political economy.

The text book instruction in the principles of chemistry and chemical physics occupies the first term of the first year. The remainder of the year the recitations alternate with laboratory practice. During the remaining years each student is expected to work two hours daily in the laboratory, five days in the week. There are four courses in laboratory practice, viz: Chemical, pharmaceutical, agricultural, and metallurgical. The work of the first year is common to all the courses, except that the qualitative analysis of brass, solder, and type metal is added to make up the metallurgical course. The work of the remaining year is especially devoted to the end indicated by the names of the courses. The special work of the agricultural course includes the analysis of soils, ashes of plants, fertilizers, and agricultural products, and the preparation of organic and inorganic salts and compounds.

THE SCHOOLS OF NATURAL HISTORY, MILITARY SCIENCE, AND ART.

The aim of this school is to give a liberal scientific education. As its name testifies, it teaches the sciences connected with man and his habitation. The special studies are botany, vegetable physiology, anatomy and physiology, zoölogy and taxidermy, geology, paleontology, microscopy and fungology, and osteology. The school has a large collection of specimens in the departments of botany, entomology, zoölogy, and geology.

In addition to these colleges and schools properly related to technical and other pursuits, there are schools of military science, of art and design, of ancient languages, and of English and modern languages.

The courses in the school of military science are as follows:

First year.—School of the soldier and company; bayonet-fencing.

Second year.—School of battalion; skirmish drills; ceremonies and reviews; military signaling; sword-fencing; guard, outpost, and picket duty.

Third year.—Military administration; reports and returns; theory of fire-arms; target practice; artillery drill; organization of armies; art of war; field fortification.

The school of art and design furnishes instruction in free-hand drawing, and offers facilities for pursuing studies in industrial designing and other branches of the fine arts. Music is not a part of the university course, but a proper arrangement has been made for students who desire tuition and practice.

THE COLLEGE OF LITERATURE AND SCIENCE.

This is divided into two schools: English and modern languages, and ancient languages and literature. The purpose is to give a good general and liberal collegiate education; also to enable special students in the technical schools who may determine to become instructors, as teachers or writers, to acquire that command over languages and literature which most readily puts the work at their disposal and command. A prominent aim of the university is "the furnishing of teachers to the industrial schools of the country, and investigators and writers for the arts."

THE BUILDINGS AND THEIR USES.

The special report of the regent continues: The university main building, 214 feet in front by 122 feet in flank, occupies three sides of a quadrangle. It is five stories high, including basement and mansard; at the principal angles are two lofty towers, carrying a clock and a bell. The structure is well built of pressed brick upon a stone basement; its cost was $175,000. The main front is occupied by class rooms and offices; in the wings are several spacious apartments, 60 by 80 feet, used respectively for chapel, laboratory for physics, drawing room, museum of natural history, library, art gallery, and museum of engineering art. There are ample dressing rooms, work rooms, offices, and rooms for storage; and in the mansard story halls for literary and scientific societies. The entire building is lighted with gas and heated by steam.

The chemical building is 126 by 74 feet, and four stories high. It contains two laboratories, two lecture rooms, &c.

The mechanical building is 124 by 80 feet. In the lower story is the machine shop, with pattern room, machine room, and engine room; the carpenter's shop, with bench room and machine room, and a room for storing two field pieces. The second story is a drill-hall, with space sufficient for the evolutions of a company of infantry or a section of artillery. This room is supplied with gymnastic apparatus. This building also contains an armory and a printing office.

The greenhouse is 70 by 24 feet, with adjacent class room, work room, and propagating pits. The buildings also comprise a veterinary laboratory, hospital, and dissecting room, two spacious barns, two dwelling houses, two small dwellings used as dormitories, a small astronomical ob- servatory, lately rebuilt, a dairy house, and a farmer's cottage.

LABORATORIES, WORKSHOPS, AND COLLECTIONS.

The library contains over 13,000 volumes, selected by the various professors for reference in their several departments. The apartment is used also for a reading room, where books are consulted, but whence they cannot be taken, except by special permit. The reading room is opened during the daytime, and is greatly frequented.

The museum is well supplied with cases, which contain specimens of all the larger mammals of the United States, with very considerable collections in all the departments of zoölogy, geology, and mineralogy, and a set of Ward's casts of celebrated fossils. The specimens in the museum have mostly been prepared and mounted by the students, under the direction of their instructors. The students have been employed to mount specimens for the State museum and other cabinets.

The art gallery contains in statues, full size and reduced, busts, bas-reliefs, &c., 400 casts. It has also photographs, autotypes, and other copies of masterpieces of painting from all the noted modern schools of art. This collection represents no part of either the Congressional or the legislative grants, but is the donation of the citizens of Champaign and Urbana and of the faculty of the university. It attracts many visitors and renders notable service to the school of art and design.

The physical laboratory has a collection of apparatus which has cost over $5,000. The room is newly arranged and is well adapted for practical experimenting by pupils. The lecture room adjoining will seat 350 persons; it can be made available for experimenting by day or evening.

Special collections for illustration in mechanical, civil, and mining engineering, and in architecture, are found in their respective class rooms. They include models of mechanical movements made in the university shops; mining models and metallurgical apparatus from Freiberg; engineering and surveying instruments in abundance; models of

bridges, trusses, roofs, and stairs, also made in our own shops, &c. This material will soon be gathered in the museum of engineering art.

The chemical laboratories are arranged in the latest and most approved manner. Each student has a desk furnished with closets, reagents, water, gas, and gas-hood, so that his researches may go on without inconvenience to any other. The rooms are ventilated by a powerful fan, furnishing warm or cold air as the season may require. There are 104 desks in the qualitative room and 64 in that for quantitative analysis, and all are occupied. The number of desks can be nearly doubled. There is also a private laboratory for professors; a balance room; room for gas analysis; a suite of rooms for photography; a pharmacy; and, in the basement, rooms and power for metallurgical purposes. These rooms have all been occupied. The building is heated by steam.

The machine shop has a steam engine of 16-horse power; two engine and three plain lathes; a planer; a large drill press and smaller drills; all needful bench-rooms; a pattern shop; a blacksmith shop, &c.

The students in this department have, during the freshman year, an elementary drill in wood and iron work with the cold chisel, the file, at the anvil, and at the machine tools. Afterwards they are employed in simpler and more complex designs in work for the shop or for customers.

The engine, the large drill press, three of the lathes, and other machines or parts of machines now in use were built in the shop, as were the engine, pump, and other mechanism under the chemical laboratory.

The carpenter's shop is similarly supplied with necessary machine tools, as saws, planers, tenoning machine, whittler, &c. Its power is furnished by the machine shop. A course of elementary wood construction is followed by such actual practice as occasion may offer. This shop has hitherto found abundance of work in building cabinets for the museum, cases for the library, and other work demanded in the development of other departments.

Drawing, free-hand, projection, mechanical, and architectural, and in the departments of botany and zoölogy, is taught as the handmaid of every science. One of the larger rooms is devoted to this purpose, having a large supply of models, casts, and similar material. Special rooms are set apart for architectural, mechanical, and engineering drawing. A room is given to modelling in clay and casting successful designs in plaster.

The botanical work-room has a supply of compound microscopes; the objectives and four stands have been bought abroad; a larger number of cheaper but thoroughly serviceable stands were made in the university machine shops. A tract of land is set apart for culture of rare or otherwise desirable plants. Experiments in horticulture, with practice in tree planting, grafting, budding, and other means of propagation are regularly performed or taught to classes.

The university groumds make a good study in landscape gardening. An arboretum has about 100 varieties of exotic and indigenous trees. An orchard has been planted with 1,000 varieties of apples, now bearing fruit, besides pears, peaches, grapes, and other small fruit.

The stock farm occupies about 400 acres; the experimental farm about 70 acres. The stock barn has the form of an L, the longer sides being 80 feet, and the breadth of each wing 40 feet. It is of wood, over an ample stone basement. Another barn nearer the house of the professor of agriculture is specially adapted to the housing and care of the small herd of choice cattle of recorded pedigree, chiefly short-horns and Jerseys.

A farmers' institute is held at the university in January of each year, occupying about a week. The labor is done mainly by the professors, in addition to their ordinary duties. The attendance is large, and each year the interest is greater. The information disseminated is bearing good fruit in the improved intelligence of the farming community in the vicinity.

MISCELLANEOUS.

Women are admitted to any of the university courses; most choose the course of literature and science. A course of studies under the general head "Domestic Science" was arranged specially for women, and was in use for five years. Thirty-one persons have chosen this course, and six have taken the degree of bachelor of science in this school.

Unless excused for actual physical disability, all the male students of the university are drilled during the first three years of their college course by an officer of the Regular Army, detailed for this duty by authority of an act of Congress.

The armory contains 300 Springfield cadet breech-loading rifles, with the necessary equipments, side arms for officers, and two six-pounder field pieces. A campus of about 10 acres, beautifully levelled and fringed with evergreens, furnishes space for evolutions in the season for out-of-door exercise. At other times the drill is conducted in the hall, already mentioned. A band of about fifteen pieces, the players being students, furnishes music for the drill, for marching to the chapel daily, and for the various other occasions which arise.

The university maintains a close connection with the public schools of the State. Such of the high schools as desire, after an examination by a committee of the faculty and a satisfactory report, are placed upon an "accredited list." Graduates from these schools are admitted to the freshman class of the university without any examination. About one-third of the last class (1880) were admitted in this way, upon exhibition of their diplomas. * * *

In every department of life, as professional men, teachers, merchants, engineers, farmers, naturalists, our graduates, and those who have gone out from us after a shorter residence without remaining to finish any distinct course of study, are doing honest and faithful work, serving their country and adorning the fair fame of their *alma mater*.

It will be remembered that the university was organized but fourteen years prior to the date at which this report ends, and that but eleven classes have passed out as graduates.

The Illinois Industrial University, as it stands to-day, whether considered with reference to its outlined plans of study, scientific, practical, esthetic; its present standards of scholarly attainment; its generous equipment in lands, buildings, laboratories, museums; the character and learning of its able corps of instructors; or the manly and womanly earnestness and high purposes which pervade the whole body of its under-graduate members, all these characteristics which are the sources of gratified surprise to whoever examines its present condition, attest the wisdom of its founders, and particularly emphasize the eminent success of its first president, under whose vigorous hand and fertile brain its destinies were guided for twelve years.

To John M. Gregory, LL. D., its first regent, the university and the people of Illinois owe a debt which can never be discharged, but whose magnitude will be more fully appreciated with each revolving year.

INDIANA.

PURDUE UNIVERSITY.

[Statements from the latest reports received by this office.]

HISTORICAL STATEMENT.

Purdue University is located at La Fayette, Ind., and has been in operation since September, 1874. It was first organized exclusively upon the basis of special schools for technical studies, but after two years' experience the institution was reorganized on the plan described below, which, though more fully developed, has remained substantially unchanged.

John Purdue, after whom the university is named, donated $150,000 on condition that the institution should be located within Tippecanoe County; the county gave $50,000, and four citizens 100 acres of land.

ENDOWMENT.

The proceeds of the sale of the land (390,000 acres) amounted to $212,238.50. This endowment has been increased largely, and now amounts to $340,000. The buildings and grounds are valued at $250,000. The university has received State appropriations, from 1873 to 1882, amounting to $148,000.

Receipts and expenditures for 1880–'81.

Interest on land grant endowment	$17,161 25
State appropriations	4,500 00
Current receipts from fees, etc	3,084 48
Current receipts from farm	2,053 85
Balance in treasury July 1, 1880	7,548 77
Total receipts	34,348 35

The expenditures were as follows:

Salaries of instructors	$16,483 35
Other running expenses	11,015 03
Improvements	3,489 35
Running expenses of the farm	1,571 51
Total expenditures	32,559 24



Boarding House. Ladies' Hall. Industrial Art Hall. Laboratory. Engine House. Mechanics' Shop. University Hall. Men's Dormitory. Military Hall.

PURDUE UNIVERSITY, LA FAYETTE, IND.

The State appropriations prior to 1881 were made for definite purposes. In 1881 the legislature appropriated $20,000 for 1881 and $20,000 for 1882, to be expended at the discretion of the trustees.

THE FACULTY.

The faculty consists of 11 professors and instructors in the collegiate department and 2 in the preparatory, with 3 assistants; in all, 16 instructors. They are the president, who is also professor of intellectual and political science, the professors of chemistry and physics, of the natural history sciences, of mathematics, of industrial art, of agriculture and horticulture, of English and history, of German, the instructors in mechanics, and in Latin and elocution, the principal and assistant in the academy, an assistant chemist, and two assistants teaching one class each.

The employés are a librarian and registrar, farmer, horticulturist, and engineer (who is also superintendent of buildings), a janitor, and assistant workmen in the engine house on the farm and in the experimental station.

STUDENTS.

The total number of students in the college proper (1881–'82) was 99; in special schools, 61; in the preparatory department, 129.

Fifty-one of the students in the special schools were also enrolled in the college or academy, so that the total number of different students is 238. There were 68 appointed students in attendance. No distinctions on account of sex are made. The university contained during the school year 1880–'81, 30 women students in college, 13 in special schools, and 52 in the academy. Of those in special schools, 10 were in the industrial art school, 2 in the school of mechanics, and 1 in the school of chemistry. The fees are small, and it requires an annual expenditure of only $160 to meet them and to pay for board and necessary expenses. The students appointed by counties (2 may be appointed by each county) are relieved from expenses to the amount of $33 a year.

DEPARTMENTS AND WORK.

Purdue University embraces three departments, designated as follows:

1. The college of general science.
2. Special schools of science, agriculture, and the mechanic arts.
3. The university academy.

The college provides four general courses of study, viz: The scientific course and three industrial courses, designated as the agricultural course, the mechanical course, and the industrial art course. These courses are so arranged that they include nearly the same instruction in science, mathematics, industrial drawing, English history, and political and intellectual science; and the completion of any one of them entitles a student to the degree of bachelor of science.

These four regular courses are as follows:

1. *Scientific course.*

The aim of the scientific course is to give a thorough scientific education as a general preparation for all industrial pursuits; and, secondly, as an adequate preparation for special courses of study. The natural and physical sciences are the *leading* branches in the course, requiring about one-third of the student's time for the entire period of four years. It also gives unusual prominence to industrial art.

The regular course is as follows:

FRESHMAN YEAR.—(*a*) Biology and botany; (*b*) geometry and algebra; (*c*) industrial drawing; (*d*) Latin or German or English.

SOPHOMORE.—(*a*) Zoölogy and physics; (*b*) higher algebra, trigonometry, and surveying; (*c*) ancient, mediæval, and modern history; (*d*) Latin or German.

JUNIOR.—(*a*) Chemistry; (*b*) analytical geometry and astronomy; (*c*) rhetoric and English literature; (*d*) Latin or German.

SENIOR.—(*a*) Higher physiology and geology; (*b*) political economy, United States Constitution, and intellectual science; (*c*) the calculus and logic, or an advanced course in chemistry or botany or zoölogy.

The university has a well-equipped chemical laboratory, a good biological laboratory, a choice museum of natural history, a large geological cabinet, and other first-class appliances for scientific instruction and training.

2. *Agricultural course.*

The agricultural course aims not only to give a good scientific education, but also to impart a thorough and practical knowledge of the principles of agriculture and horticulture. It gives special attention to scientific experiments.

The regular full course is as follows:

FRESHMAN YEAR.—(*a*) *Stock, stock breeding, comparative anatomy, veterinary obstetrics,* and *veterinary science;* (*b*) biology and botany; (*c*) geometry and algebra; (*d*) industrial drawing.

SOPHOMORE.—(*a*) *Crops* (methods of tillage, rotation of crops, &c.), *meteorology, drainage,* and *farm management;* (*b*) zoölogy and physics; (*c*) higher algebra, trigonometry, and surveying; (*d*) ancient, mediæval, and modern history.

JUNIOR.—(*a*) *Pomology, floriculture, forestry, entomology, landscape gardening,* and *market gardening;* (*b*) chemistry; (*c*) analytical geometry and astronomy; (*d*) rhetoric and English literature.

SENIOR.—(*a*) *Agricultural chemistry* and *special studies and experiments in agriculture;* (*b*) higher physiology and geology; (*c*) political economy, United States Constitution, and intellectual science.

Due attention is given to English composition.

The students who take the above course are required to work two hours daily in the experimental field, campus, nursery, orchard, &c., during the fall and spring terms (receiving pay for satisfactory work), and in the mechanics' shop during the winter term. This manual labor not only imparts increased skill but it also fosters an active interest in industrial pursuits.

The first two years of the full course outlined above constitute a short course in agriculture. The young man who completes this course will acquire a good knowledge of the principles and methods of agriculture, and at the same time he will obtain a higher practical education for all the duties of life.

The branches of study printed in italics in the above course constitute a special course in agriculture and horticulture. All students who take this special course are required to pursue the corresponding natural and physical sciences. Students who have a fair knowledge of botany and zoölogy can complete the first two years of this special course in one year.

The agricultural department of Purdue University is well equipped for thorough instruction and practice. It occupies a commodious building ("Agricultural Hall"), recently erected, and its means of illustration include the university farm, experimental station, conservatory and propagating house, nurseries, orchards, &c.

The experimental station of a ten acre plat is well laid out and devoted to experiments in agriculture and horticulture with promise of great success and marked utility. The experiments in 1881 included thirty-two varieties of wheat, forty-nine varieties of potatoes, twenty-three varieties of grapes, and a number of varieties of strawberries, raspberries, and other small fruits. Twenty plats of corn were used for experiments with fertilizers. This department is supplied with a full set of meteorological instruments purchased through the United States Signal Service Office. The weather observations are carefully made and recorded, and a full statement of the same is published in the annual report of the university.

3. *Mechanical course.*

The regular mechanical course is as follows:

FRESHMAN YEAR.—(*a*) Shop practice in *carpentry, wood turning, pattern making,* and *vise work,* with instruction in *carpentry, pattern construction, casting* and *founding* and *machine drawing;* (*b*) geometry and algebra; (*c*) industrial drawing; (*d*) English.

SOPHOMORE.—(*a*) Shop practice in *forging* and *machine work,* and instruction in *machine drawing, mill work,* and *machinery;* (*b*) higher algebra, trigonometry, and surveying; (*c*) physics.

JUNIOR.—(*a*) *Mechanical engineering,* or German; (*b*) chemistry; (*c*) analytical geometry and astronomy; (*d*) rhetoric and English literature.

SENIOR.—(*a*) *Mechanical engineering,* or German; (*b*) higher physiology and geology; (*c*) calculus and logic; (*d*) political economy, United States Constitution, and intellectual science.

The first two years of this course furnish an excellent technical training for a mechanic or machinist, and also afford a good preparation for a course in mechanical and civil engineering. The course provides two years of shop practice (two hours daily) in the use of hand and machine tools for working in wood and iron; one year's instruction (one hour daily) in the elements of carpentry, pattern making, founding, mill work, &c., and one year's instruction in mechanical drawing, thus including the elements of all the common trades; and, at the same time, the course for these two years provides instruction in mathematics, physical science, and English.

This may be followed with two years' instruction in mechanical engineering, taken in connection with the branches in the corresponding terms of the scientific course.

The branches of study and practice printed in italics in the first two years of the above course constitute a special course in practical mechanics, and may be taken by those who have the necessary knowledge of algebra, geometry, and drawing.

The shops are supplied with tools and machines of a superior quality and specially adapted for the work for which they are used. They include complete appliances for bench work in wood, machine work in wood, vise work in iron, machine work in iron, and forging.

The method of mechanical instruction and training employed in Purdue University is clearly set forth in a statement by Prof. M. F. M. Goss, instructor in mechanics, which is presented by Prof. John D. Runkle, Ph. D., LLD., of the Massachusetts Institute of Technology, in a paper on "The Manual Element in Education." Professor Goss's statement is given below.

The shop instruction is divided as follows:

Bench work in wood	12 weeks (120 hours)
Wood-turning	4 weeks (40 hours)
Pattern-making	12 weeks (120 hours)
Vise-work in iron	10 weeks (100 hours)
Forging in iron and steel	18 weeks (180 hours)
Machine tool work in iron	20 weeks (200 hours)

The object of the shop instruction is, first, to prepare students for a course of mechanical engineering, and, second, to provide a preparation for some industrial pursuit.

Method of instruction.—We have series of unchanging principles which must be taught practically through the use of corresponding sets of tools; and, while series of models are principally used, we vary these with each class in form and dimensions, always keeping in view the principles to be taught. Another feature is to make the models assume a form which may, if possible, afterward be utilized. The principles involved will always be of prime and the utilization of secondary consideration.

Course in carpentry and joinery.—1, exercise in sawing and planing to dimensions; 2, application, a box nailed together; 3, mortise and tenon joints; a plain mortise and tenon, an open dove-tailed mortise and tenon (dovetailed halving); a dovetailed keyed mortise and tenon; 4, splices; 5, common dovetailing; 6, lap dovetailing and rabbeting; 7, blind or secret dovetail; 8, mitre-box; 9, carpenter's trestle; 10, panel door; 11, roof truss; 12, section of king-post truss roof; 13, drawing model. Elements applied in simple forms in each case.

Wood-turning.—1, elementary principles—first, straight turning; second, cutting in; third, convex curves with the chisel; fourth, compound curves formed with the gouge; 2, file and chisel handles; 3, mallets; 4, picture frames (chuck work); 5, card-receiver (chuck work); 6, match-safe (chuck work); 7, ball. The articles present good forms for learning the art, and each of the last four a new and difficult feature of chucking.

Pattern-making.—The student is supposed now to have some skill in bench and lathe work, which will be increased; but the direct object is to teach what forms of patterns are in general necessary, and how they must be constructed in order to get a perfect mould from them. We have not thought it necessary that each student should do the same examples to accomplish this object. In this way the work has been much more varied; each student learns the peculiar features in the work done by his neighbor, and gets a much broader knowledge than could in the same time be acquired in any other way. The work is, consequently, somewhat different each year; for the year just passed, besides simple patterns easily drawn from the sand, such as glands, ball-cranks, &c., there followed a series of flanged pipe-joints for 2½-inch pipe, including the necessary core boxes, in which all took part; then pulley patterns from 6 to 10 inches in diameter, built in segments for strength, and to prevent warping and shrinkage; lastly, a complete set of patterns for a three-horse power horizontal steam engine, all made from drawings of the finished piece.

"*Vise work in iron.*—1. Given a block of cast iron 4 inches by 2 inches, by 1½ inches in thickness, to reduce the thickness ¼ inch by chipping and then by finishing with the file. 2. To file a round hole square. 3. To file a round hole into elliptical. 4. Given a 3 inch cube of wrought iron to cut a spline 3 inches by ⅜ inch, by ¼ inch, and second, when the under side is a one-half round hollow. These two cuts involve the use of the cape chisel and the round nose chisel, and are examples of very difficult chipping. 5. Round filing, or hand vise work. 6. Scraping. 7. Some special examples of fitting.

"*Forging.*—1. Elementary processes, drawing, bending, upsetting. 2. A course in welding. 3. Miscellaneous forgings, intended to represent different principles in forming. 4. Steel forging, including hardening and tempering in all its details.

"*Machine work.*—In this course we have used few set models, the work varying more or less with each class. But the aim is to teach centring, plain and taper turning, taper fitting, screw cutting, to bring in all the adjuncts of the machines, and to give practice in their use. All students are not upon the same work at the same time; but each during his course has an opportunity of learning the use of all the tools and appliances. Nor is a given time allotted to each piece. The slow ones must work extra time to keep up,

while those who are quick are given extra work. All students are required to devote all the time allotted to each shop course, and not allowed to pass from one to another in advance of the class, unless they are proficient and can enter a regular class in an advanced branch.

"The shop instruction is supplemented by a course of lessons on the theory of the hand and machine tools, more or less use being made of Shelley's Workshop Appliances, Holly's Laws, Rose's Pattern Maker's Assistant, Rose's Practical Machinist, and notes notes found in the first two volumes on Building Construction, published by Rivingtons."

4. *Industrial art course.*

Instruction in industrial drawing has been provided for from the beginning of the university, and such instruction is made an important element in all the regular courses of study. The more advanced instruction has been given to special students, or to regular students who have been able to continue industrial art as an extra study.

The importance of this training and the interest of students in it have resulted (1882) in the adding of an industrial art course to the regular industrial courses. It is as follows:

FRESHMAN YEAR.—(*a*) *Industrial drawing* (1 year); *clay modelling* (15 weeks) and wood carving; (*b*) geometry and algebra; (*c*) biology and botany; (*d*) English.

SOPHOMORE.—(*a*) *Industrial art* (see below) and *industrial design;* (*b*) higher algebra, trigonometry, and surveying; (*c*) zoölogy and physics.

JUNIOR.—(*a*) Chemistry; (*b*) analytical geometry and astronomy; (*c*) rhetoric and English literature; (*d*) Latin or German.

SENIOR.—(*a*) Higher physiology and geology; (*b*) political economy, United States Constitution, and intellectual science; (*c*) Latin or German; (*d*) *special study in industrial art.*

The course in industrial drawing in the freshman year includes geometrical drawing (about 100 problems), perspective, orthographic projection, isometric projection, and model and object drawing.

The course in clay modelling includes the modelling of geometrical solids, followed by architectural ornaments, fruits, flowers, parts of the human body, &c.—an excellent preparation for work in wood, iron, glass, plaster, stucco, &c.

The course in wood carving includes diaper carving, incised carving, low relief carving, and higher relief carving, including tablets, panels, sculptured ornaments, &c.

The course in industrial art in the sophomore year includes drawing in light and shade, light and color, and historical ornament; and the course in industrial design includes the analysis of plant forms for purposes of design, and the making of original designs for prints, carpets, lace, wall paper, oil cloths, tiles, china ware, &c.

Students who do not wish to take the full course, outlined above, can take a special course, made up of branches printed in italics in the above full course, and devote all their time to it.

The industrial art department is provided with a suit of rooms specially fitted for the different courses, and is well supplied with casts, models, copies, charts, and other appliances required for thorough art instruction and practice. It is believed that no industrial college in the country has a better equipped or more successful art department than Purdue University.

Conditions of admission.

Applicants for admission to the freshman class (to take any one of the four courses given above) must pass a satisfactory examination in spelling, geography, English grammar, arithmetic, elementary algebra (including quadratic equations), the history of the United States, physical geography, and physiology. An applicant's knowledge of the common branches must be sufficient to entitle him to a teacher's certificate of good grade, and his knowledge of the elements of algebra should be thorough. Applicants who have completed their course of preparation in high schools that hold the certificate of the State board of education will be admitted without examination.

Entrance examinations are held in the several counties of the State, under the direction of county superintendents, and also at the university.

Special schools.

The several departments of the university which provide special instruction for students who wish to pursue branches as *specialties* are called *special schools.* The following special schools have been organized:

1. School of agriculture and horticulture.
2. School of practical mechanics.

3. School of industrial art.
4. School of chemistry.
5. School of natural history.
6. School of mechanical and civil engineering.

The courses of instruction and practice in the special schools of agriculture and horticulture and practical mechanics include the studies printed in italics in the regular courses given above, and correspond to what are there designated "special courses." The conditions of admission to either of these schools are the same as the conditions of admission to the freshman class.

The course of instruction and practice in the special school of industrial art takes a wider range of art studies than the regular course. The course in clay modelling and wood carving is similar to this element of the regular industrial art course, but is more extended and thorough.

The course in industrial design (drawing) covers two years. The first year is the same as the sophomore year of the regular industrial art course. The second year is mainly devoted to the designing of articles of manufacture and their ornamentation.

The course in mechanical drawing for the first year is the same as the first year's course in industrial design, except that the details of machinery form part of the instruction in instrumental drawing.

The instruction in the second year includes drawings made to scales of engines and other machines; drawings of machines from measurements; drawings from given data; original designs for machines, giving plans, elevations, sections, &c.; and orthographic projection, development of surfaces, descriptive geometry, &c.

The special school of chemistry is open to students who have completed the first two years of one of the regular courses of the college or an equivalent. The first year of the course is the same as the course in chemistry prescribed for the junior year of the scientific course.

The course for the second year includes lectures on qualitative and quantitative analysis, including minerals, soils, fertilizers, &c., with laboratory practice ten hours per week.

The third year's course is arranged under the three divisions of mineralogy, metallurgy, and organic chemistry. The students in metallurgy are required to take the course in mineralogy. The practice includes from six to eight hours of daily work in the laboratory.

Students who complete a three years' course in this school are entitled to the degree of analytical chemist (A. C.).

The chemical laboratory is well equipped for thorough work in each branch of study, and the instruction looks to direct practical applications. The professor of chemistry is the State chemist, and as such is charged with the duty of analyzing all fertilizers offered for sale in the State. The laboratory also renders the State board of health important assistance.

The special school of natural history provides two courses of two years each, one in botany and one in zoölogy, each course being open to students who have a knowledge of biology, botany, and zoölogy, as taught in the scientific course, or an equivalent.

The course in botany in the first year includes advanced instruction in structural and systematic botany, histology, organogeny, and embryology of phanerogams. The first term of the second year is devoted to cryptogams, and the second and third terms are devoted to original work preparatory to a thesis.

The course in zoölogy during the first four terms is a study of the comparative anatomy of the various classes of animals by dissection. During the last two terms students devote themselves to special original work and are required to present a thesis.

The biological laboratory is supplied with simple and compound microscopes, reagents, and dissecting tables, thus furnishing ample facilities for practical work. The geological cabinet contains valuable collections of minerals, fossils, archæological specimens, &c. The zoölogical museum contains important collections in conchology, entomology, ornithology, and other branches. The herbarium has over 2,000 specimens, and is specially well supplied with sets of State grasses, sedges, and ferns.

The school of mechanical and civil engineering was to be organized in September, 1882. It will be open to students who have completed the first two years of the regular mechanical course, or an equivalent. The course of instruction will cover a period of three years. The first two years may be taken in connection with junior and senior studies in the regular college course.

The university academy.

The academy has the two-fold object of preparing students for admission to the freshman class and of providing thorough instruction in the higher common school branches for those who cannot take a more extended course. It thus fills the gap between the

common country school and the college. It is in charge of first class teachers, and is provided with commodious rooms and other appliances necessary for thorough and practical instruction.

Applicants for admission must have a fair knowledge of spelling, geography, arithmetic, and English grammar as taught in the better class of country schools. Students who have a thorough knowledge of the common branches can prepare for the freshman class of the college in one year.

Other advantages.

The *military department* is in charge of Lieut. W. R. Hamilton, U. S. A., detailed by the War Department as instructor in military tactics in Asbury University and permitted by the Secretary of War to occupy the same position in Purdue University. The cadets receive two to three drills a week.

Four *literary societies*[1] are open to students: the Irving, the Philalethean, the Carlyle, and the Periclean, the first and third for young men, the second for young women, and the fourth for academy students of both sexes. The exercises are an efficient means of improvement in writing and speaking. The college societies have commodious halls, neatly carpeted and furnished. A branch of the Young Men's Christian Association was organized in 1880, and is well sustained by the students.

The *library* occupies a commodious and well-lighted room, appropriately fitted and furnished. It contains a valuable collection of books of reference in each department and a goodly number of miscellaneous works, many of standard value, the number of volumes being over 2,000. It also contains many periodicals, scientific, industrial, and literary.

BUILDINGS AND GROUNDS.

The main college building, "University Hall," contains a chapel or assembly hall, an academy hall, two large society halls, a library, and fifteen other rooms used for recitations and other college purposes. The other buildings are the laboratory, containing also the mechanics' shop, the "boarding house" (containing the ladies' dormitory, a complete suite of rooms for the department of industrial art, and a spacious dining hall and other rooms for boarding purposes), the young men's dormitory, the Agricultural Hall, the Military Hall, the boiler, engine, and gas house, and the Peirce Conservatory. There are also a dwelling house for the engineer, a farm house, barn, stables, and other buildings. The entire group of college buildings is heated by steam and lighted by gas.

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[1] The regulations of Purdue University forbid its students from joining or having any active connection with college secret societies. The regulations upon the subject are as follows:

"No society is permitted to be organized by the students, except by consent of the faculty, and the public exercises of the societies thus organized are subject in time, place, and character to the approval of the faculty.

"No student shall join or have any active connection as a member, or otherwise, with any so-called Greek fraternity or other college secret society or with any other students' society not authorized by the faculty; and, as a condition of graduation or honorable dismission, students shall be required to sign a written statement that they have complied with this regulation."

As a condition of admission to the university or any department therein or of re-entrance, students shall be required to subscribe to the foregoing regulations, and all other regulations of the university relating to the obligations and duties of students, and promise a faithful compliance therewith during their connection with the university; that is, until dismissed or graduated.

PLEDGE.

"I hereby subscribe to the foregoing regulations and all other regulations of Purdue University which relate to the duties and obligations of students, and I promise on my honor a faithful compliance therewith during the university year ending June 30 next."

The power of the Purdue authorities to prohibit the connection of students with college secret societies is thus affirmed by the supreme court of Indiana in an opinion revised August 15, 1882:

"It is clearly within the power of the trustees, and of the faculty when acting presumably or otherwise in their behalf, to absolutely prohibit any connection between the Greek fraternities and the university. The trustees have also the undoubted authority to prohibit the attendance of students upon meetings of such Greek fraternities or from having any other active connection with such organizations, so long as such students remain under the control of the university, whenever such attendance upon the meetings of or other active connection with such fraternities tends in any material degree to interfere with the proper relations of the students to the university. As to the propriety of such and similar inhibitions and restrictions, the trustees, aided by the experience of the faculty, ought and are presumed to be the better judges, and as to all such matters, within reasonable limits, the power of the trustees is plenary and complete."

The special reasons for the exclusion of the Greek-letter fraternities from Purdue University were given in a report by the president to the board of trustees in December, 1878, as follows:

"The membership of these societies is almost exclusively in the classical colleges, and they necessarily represent the classical and professional spirit. Purdue University is an *industrial* institution and its students must be imbued with an industrial spirit. Its success requires that the dominant, controlling influence of the institution be scientific and industrial, not classical. The multiplication of Greek societies, in close alliance and under the influence of the chapters in the classical colleges, would antagonize and supplant the industrial spirit in Purdue and give its agricultural and mechanical departments the 'dry rot.' No industrial school can prosper if secretly sapped by the adverse influence of the classical system."

The campus and horticultural grounds contain 20 acres, and are so laid out and cultivated that they well illustrate landscape gardening and horticulture. The nursery and grounds contain some 2,500 trees and shrubs, and the conservatory and propagating house are filled with choice plants. The lawns and ornamental plats are kept in excellent condition. The university occupies one of the handsomest, as well as healthiest, college sites in the country.

IOWA.

STATE AGRICULTURAL COLLEGE.

The objects of the Iowa Agricultural College are clearly set forth in the language of the Congressional law, which declares that its course of study and organization shall be made "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life," and the entire management and policy of its officers have, from its opening to the present time, aimed to secure this important purpose.

ENDOWMENT AND FUNDS.

The endowment consists of the proceeds from the sale and rent of 204,309 acres of land, and the annual income therefrom amounts to $41,000.

The regular annual expenditure is the same as the income, viz: $41,000. The annual expense of teaching staff is $26,000.

THE FACULTY.

There are 22 instructors, divided so as to give the school of agriculture 1; of horticulture, 1; of veterinary science, 2; of domestic economy, 1; of military tactics, 1; of literature and language, 2; of mathematics and physics, 2; of chemistry, 2; of biology, 3; of philosophy, 3; of mechanical engineering, 2; of civil engineering, 2.

STUDENTS AND GRADUATES.

In 1881 the attendance was as follows: Number of young men, 159; young women, 67—total, 226. Tuition is free. There are no scholarships. The number of graduates was, in 1880, as follows: Young men, 122; young women, 43—total, 165.

Classified according to degrees conferred, they stood as follows: Agricultural course, B. S., 83; mechanical engineering, B. M. E., 8; civil engineering, B. C. E., 31; ladies' course, B. S., 43—total, 165.

The occupations of graduates as far as ascertained are: Teachers in agricultural colleges and agricultural departments, 10; farmers, 20; ministers, 2; book-keepers, 10; principals of schools, 18; teacher in Deaf and Dumb College, 1; inventor, 1; business men, bankers, merchants, &c., 6; physicians, 7; veterinary surgeons, 2; lawyers, 21; engineers, surveyors, and architects, 10; editors, 2; deceased, 6; unknown, 1; printers, 2; students, 3; ladies' pursuits, unknown, 43—total, 165.

ORGANIZATION OF CLASSES AND INSTRUCTION.

The several branches taught are arranged in courses known as general and technical. The general course aims to give a liberal culture in the sciences and other branches of learning, without especially confining it to any particular pursuit or profession. The technical course aims to direct a liberal culture, so as to meet the requirements of some particular industrial pursuit or profession. The technical courses are pursued as follows:

I. The school of agriculture.

II. The school of engineering, embracing two courses—mechanical and civil.

III. The school of veterinary science.

In addition to these defined courses there "are certain lines of technical and scientific study, which include either a single prominent science or several closely-related ones, which may be pursued exclusively by students properly qualified. These, however, do not lead to any degree, but any student completing the studies of any such line may receive the college certificate showing his standings in such studies." These are designated: 1, domestic economy; 2, military science; 3, literature and language; 4, mathematics and physics; 5, chemistry; 6, biology; 7, philosophy.

The two terms of the freshman year and the first term of the sophomore year are filled with certain required and antecedent studies, common to all the schools, except

that of veterinary science. There are certain "additional studies" which increase the efficiency of the preparation. The general "course in sciences related to the industries" provides for the degree of bachelor of science and embraces the following studies: In the freshman year, besides algebra, geometry, book-keeping, drawing, composition, elementary botany, and descriptive zoölogy, with optional studies of Latin, German, rhetoric, or moral science, there are, for young men, practical agriculture and horticulture, with military drill; and for young women, domestic economy and work.

The first term of the sophomore year provides for botany, chemistry with laboratory practice, zoölogy, and physics (mechanics of solids, liquids, and gases). The additional studies are: for young men, plane trigonometry, land surveying, and drill; for young women, plane trigonometry, history, domestic economy, and lectures.

For the second term, the regular course for both sexes is zoölogy and entomology, laboratory practice, physics (light and sound), botany, and vegetable anatomy. For young men, additional besides drill, general chemistry and laboratory practice, analytical geometry (optional), stock-breeding. For young women, general chemistry, with practice, or analytical geometry.

For the junior year, besides English literature, botany, vegetable anatomy and physiolgy, comparative anatomy, physics (heat), laboratory practice, and political economy; the additional studies for young men are quantitative chemistry, calculus, physics (electricity, magnetism, meteorology), landscape gardening and farm engineering, organic chemistry and practice.

For young women are the following optional studies: Quantitative chemistry and practice, calculus, physics (magnetism, electricity, and meteorology), landscape gardening, domestic economy and chemistry, kitchen practice, and French. Both classes have to prepare two essays and two dissertations during junior year.

The senior year embraces geology and mineralogy; psychology; two dissertations; science of languages; classification of the sciences; and sociology, with thesis. The young men have in addition agricultural chemistry; anatomy of domestic animals, with clinics and dissections; also, veterinary medicines and lectures on food. French is the special study for young women.

The omissions and substitutions allowed to those who wish to specialize in certain sciences, are as follows:

The special student in chemistry may omit, junior year, botany or physics, comparative anatomy or landscape engineering; senior year, geology or veterinary science or science of language.

The special student in botany may omit: junior year, physics; senior year, geology or veterinary science or science of language.

The special student in zoölogy may omit: junior year, chemistry or physics, and French; senior year, geology or veterinary science and French.

The special student in mathematics and physics may omit: sophomore year, botany or zoölogy; junior year, botany, comparative anatomy, or landscape engineering; senior year, geology, or veterinary science, or agricultural chemistry, or science of language.

The special student in veterinary science may omit, senior year, geology, science of language.

THE SCHOOL OF AGRICULTURE.

Its special faculty, besides the president, embraces professors of practical and experimental agriculture, of horticulture, of veterinary science, of chemistry, of physics, of botany, of zoölogy, and of entomology.

The design of the course is to furnish a broad and thoroughly practical education, giving it such direction as will be especially applicable to the life and duties of the farmer. It has been framed to combine that knowledge and skill which will best prepare the pupil for the highest demands of agricultural industry, and to meet the requirements of of an educated citizenship. Particular attention is paid to the problem of economic production and to the reduction of farm improvement and management to a science which shall eliminate, as far as practicable, elements of uncertainty, and foster well-defined principles of assured success. In this special line of instruction it is the purpose to evolve the science in agriculture as distinct from pure skill and from the sciences relating to agriculture. This course includes four years of college work. The distinctive work of the school is divided into two departments: agriculture and horticulture.

During the freshman year especial attention is paid to descriptive zoölogy and the management of live stock; also to dairy work. To illustrate and demonstrate the various problems, there is upon the farm a dairy of 70 cows, composed of pure shorthorns, Holsteins, and Jerseys, and grades of the same breeds. The dairy barn will accommodate 80 cows. There is a large creamery, supplied with improved apparatus. In the sophomore year special attention is given to stock breeding and the laws of heredity, &c.

During the junior year, farm economy in all its branches is thoroughly studied. The senior year is devoted to experimental agriculture and cognate studies.

The study of horticulture and forestry begins, the former in the second term of the freshman year, and the latter with the second term of the sophomore year.

The means for practical work are: Extensive vegetable and flower gardens; ornamental grounds; experimental nurseries and orchards; small fruit plantations; forestry grounds; propagating grounds and pits under glass; collections of native and cultivated woods, and of injurious and beneficial insects; sets of abnormal and diseased growths, with fac simile fruits, casts, and a growing horticultural museum. Labor of from one to four hours a day, with usual compensation for similar work, is provided for the students.

The course of studies for the two terms of the freshmen year embraces agriculture and horticulture, in addition to elementary botany; descriptive zoölogy; algebra; geometry; drawing, &c. Garden work for twelve hours each week is added, with domestic economy and work for the young women students.

The sophomore year embraces: General chemistry; plane trigonometry; land surveying; physics; mechanics of solids, liquids, gases; horticulture; stock breeding; systematic and economic botany; entomology; general and vertebrate zoölogy; light and sound, and *analytical geometry* (optional). This year also includes practical work on the farm and grounds and in the laboratory.

The junior year embraces, besides English literature, political economy; commercial law; essays and dissertations; drill; farm economy; horticulture, with six hours practice each week; how crops feed and grow, with agricultural practice of six hours each week; vegetable anatomy and physiology, with laboratory practice; physics; heat; landscape gardening; farm engineering, and organic chemistry.

The senior year embraces agricultural chemistry and experimental agriculture, with laboratory practice; veterinary science, anatomy and physiology, diseases, treatment and medicine, with clinics and dissertations; geology and mineralogy; lectures on foods; philosophy of science; psychology, and sociology; thesis.

THE SCHOOL OF ENGINEERING.

This includes the two departments of mechanical engineering and civil engineering. The department of mechanical engineering includes a special course of instruction in architecture. For the freshman year the course of study in mechanical engineering is the same as that in the sciences related to the industries, except practice in the workshop and the study of drawing and workshop tools and appliances; the former occupies three forenoons of two and a half hours each per week, the latter one hour two afternoons per week. The workshop practice is of a general character; it is not pursued with a view to any particular trade or calling. Each student is required to make a complete set of elementary forms and to execute a series of problems which will give a general training, with excellence of finish and correct fitting.

The sophomore year is devoted to leading scientific studies, and those of the junior year are in the line of the profession.

In the junior year, the studies are more strictly technical. During the first term the various methods of laying out railway curves, putting in switches and side tracks, and setting slope stakes, are taught, together with the principles of the construction of waterworks, sewers, retaining walls, and other combined structures. Data are also taken for problems in earthwork, both excavation and embankment, and the cubic contents calculated. In pure mathematics, calculus is taught; descriptive geometry is continued, dealing with stereotomy, shades, shadows, and perspective, and isometric drawing. In the second term, analytical mechanics and the strength of materials are made prominent. During this term, also, a practice survey of a portion of a line of railway is undertaken.

The faculty consists of the president, with professors of mechanical and civil engineering (3); of pure mathematics; of physics and mechanics, and of chemistry. The degrees are B. M. E. (bachelor of mechanical engineering) and B. C. E. (bachelor of civil engineering).

The studies pursued for the last two years in the course of mechanical engineering are as follows: In the junior year, stereotomy; shades, shadows, and perspective; model drawing; differential and integral calculus; the principles of analytical, theoretical, and applied mechanics; physics, heat, electricity, magnetism and meteorology; political economy; French; and dissertations.

During the senior year they embrace principles of mechanism, theory of motors, mechanical drawing, French, psychology, geology, and mineralogy (optional), dissertations, prime movers, mechanical designing, philosophy of science and sociology, preparation of thesis. Shop practice and laboratory work are required during both years. Throughout the entire year, lectures and experimental work are added as the class advances in the different subjects. The student determines, from experiments, the laws and coefficient

of elasticity and the modulus of strength of different materials. The work in the mechanical laboratory has in view its usefulness to the mechanical engineer.

In the senior year the study of prime movers and thermo-dynamics occupies the greater part of the time. For the purpose of making tests, a fifteen-horse power Harris-Corliss engine has a Richards indicator fitted to it; a four-horse power slide-valve engine has also the indicator, a friction brake, and calorimeters fitted to it. A given amount of fuel is placed in the hands of the student, he making all the tests and determining the efficiency of furnace and engine.

The civil engineering course is begun by systematic drill in algebra and geometry during the freshman year, while plane and spherical trigonometry and land surveying, descriptive and analytical geometry are taught later in the class-room and the field if necessary. Drawing also forms part of the course.

SCHOOL OF VETERINARY SCIENCE.

This is the only distinct school of the indicated character yet formed in an agricultural college. Similar studies are followed in all such institutions, but none besides the Iowa College has made a regular school and provided for the issuing of degrees. The two years' course leads to the degree of bachelor of veterinary medicine (B. V. M.) and with a post-graduate course of one year additional that of doctor of veterinary medicine (D. V. M.).

The purpose is to furnish a practical and theoretical training in the veterinary specialty of medicine and surgery. It aims, furthermore, to prepare young men for the practical work of the veterinary profession. The course of study includes two years and embraces a portion of the studies of the course in the sciences related to the industries, together with the lectures on the technical and special topics of the course and practice in the microscopical and anatomical laboratories and the veterinary hospital.

The course of study is announced as equal to the best American schools. The departments include anatomy of domestic animals; zoölogy and comparative anatomy; histology and physiology; general and comparative pathology; pathological anatomy and histology; instruction in botany; chemistry, general and applied; laboratory therapeutics; veterinary medicine and surgery and clinics. There is a well-furnished dissecting room, a laboratory for the zoölogical class, also a microscopical laboratory. The college claims abundant conveniences for chemical and pathological lectures, studies, &c. In the course of medicine and surgery, the students assist in a large practice. Those of the senior class are made familiar with the use of instruments and the administration of medicines. Several hundreds of animals, including horses, cattle, swine, and sheep, are kept on the college farm, a large portion of there being breeding stock. Frequent inspection of these flocks and herds affords the student most valuable opportunities for observing sanitary conditions and gaining experience in obstetrical practice. The course includes about one hundred and eighty lectures. A collateral course of reading, embracing some of the best approved English works on the subjects taught, is required. In the clinics, advanced students are required to examine animals for certificates of soundness, diagnose diseases, and prescribe for the same. Hundreds of animals are presented at these examinations, for which medical or surgical advice is required; the student must exercise judgment as to the course of treatment to be pursued in these widely differing forms of disease.

Candidates for admission must be at least sixteen years of age. Before entering the classes they must pass an examination in reading, orthography, geography, English grammar, and arithmetic. The course occupies two years. Sessions begin the 1st of March and continue to the middle of November, with a vacation of two weeks in July. Candidates for graduation must be eighteen. Graduates of the science course can enter the veterinary course, and on completion receive a degree as D. V. M.

For the junior year (two terms) the studies are: General chemistry, laboratory practice; general zoölogy, laboratory practice; anatomy of domestic animals; dissections and clinics; materia medica; elementary botany; comparative anatomy; anatomy of domestic animals; veterinary medicine; dissections, and clinics.

The senior year embraces the study of medicine and surgery; medical botany; therapeutics; organic chemistry and toxicology, laboratory practice; histology and physiology, laboratory practice; comparative and general pathology, laboratory practice; veterinary obstetrics; pharmaceutical chemistry, laboratory practice; veterinary sanitary science, and police.

DEPARTMENT OF DOMESTIC ECONOMY.

The studies comprised in this course have been selected with reference simply to their value as prerequisites to a thoroughly practical education, embracing a well-balanced variety of subjects. Besides antecedent studies, the course embraces the most approved

branches of science and literature in the last five terms, and the study and practice required for systematic housekeeping.

One division of young ladies, from the freshman class in the science course, practice in the experimental kitchen from 10 to 12 every morning, helping to get dinner for the students. Each member of the class thus gives two hours a week to the study of domestic economy, and they thus learn to prepare plain food in an economical, skillful, and appetizing manner. The sophomore class receive one lecture a week on subjects connected with household management, the preservation of health, care of the sick, &c. The juniors practice two afternoons a week in the experimental kitchen, receiving instruction in the more difficult operations of the culinary art.

The freshman and sophomore years are the same as those for young women in the general scientific course, with certain additions, as above indicated. A standing of at least three (four being perfect) and a final thesis, as required by college law, are the conditions of graduation in this course. The degree is that of bachelor of science.

The studies for the junior year are as follows: Vegetable physiology, cryptogamic botany, physics, heat, English literature, quantitative chemistry, differential and integral calculus, domestic economy, domestic chemistry, French, comparative anatomy, landscape gardening (optional), physics (electricity, magnetism, and meteorology optional), political economy, and dissertations.

The senior year has the following studies: French, geology and mineralogy, psychology, dissertations, philosophy of science and sociology, science of language, and thesis.

MILITARY SCIENCE.

Lectures on military subjects are delivered throughout the course and regular military drill takes place every Wednesday afternoon as follows: First year, first term, school of the soldier; second term, school of the company. Second year, first term, school of the battalion; second term, field artillery drill. Third year, first term, broad-sword exercise and artillery drill; second term, small-sword exercise. Fourth year, first term: cavalry drill and small-sword exercise.

THE DEGREES CONFERRED.

The degree of bachelor of science (B. S. C.) is conferred upon the graduate in the course in sciences related to the industries.

The degree of bachelor of scientific agriculture (B. S. A.) is conferred upon the graduate in agriculture.

The degree of bachelor of mechanical engineering (B. M. E.) is conferred upon the graduate in mechanical engineering.

The degree of bachelor of civil engineering (B. C. E.) is conferred upon the graduate in civil engineering.

The degree of bachelor of veterinary medicine (B. V. M.) is conferred upon the graduate in that study.

The higher degrees are conferred upon the following rules and the recommendations of the faculty:

That of master of science (M. S.C.) is open to bachelors of science, who are graduates of the course in sciences related to the industries, and spend one year additional in such higher studies as may be indicated.

That of master of scientific agriculture (M. S. A.) is open to bachelors of scientific agriculture after pursuing a post-graduate course of one year.

That of mechanical engineer (M. E.) is open to bachelors of mechanical engineering under similar regulations.

That of civil engineer (C. E.) is open to Bachelors of civil engineering in the same way.

That of doctor of veterinary medicine (D. V. M.) is open to bachelors of veterinary medicine. This requires an extra year.

That of master of philosophy is open to graduates of any of the four-year courses of study, the candidates to reside one year and pursue during that time a course of study embracing at least two studies, selected with the approval of the faculty, of which the science of language, psychology, social science, or higher mathematics shall constitute the principal subjects.

GENERAL INFORMATION.

The Iowa Agricultural College has completed its thirteenth year since the formal opening in March, 1869. From its dedication at that date to the cause of industrial learning to the close of its last commencement, it has been striving steadily and successfully to accomplish the purpose set forth in the national law, which at once constitutes its charter and supplies its endowment. Whoever studies its brief history will not fail to find therein all the indications of a uniform and healthy advancement.

Manual labor is divided into uninstructive labor, which is paid for by wages, and instructive work, which forms part of the course of study and practice. The first embraces all work accruing to the benefit of the college.

Instructive labor embraces all operations in work-shop, museum, laboratories, experimental kitchen, upon farm and garden, in which the sole purpose pursued is the acquisition of skill and practice. The labor furnished by the school of agriculture, of veterinary science, and of engineering is given by each exclusively to its own special students.

The current expenses of students, board, light, heat, &c., per week is $2.86; room rent per term, 75 cents to $1.50; washing, 50 cents; janitor's fee per term, $3.

The library numbers about 6,000 volumes. It is made up almost entirely of new books, purchased since the opening of the college.

There are large and well furnished chemical laboratories, wherein a hundred students at once may engage in experimentation and analysis. They cover a space of 4,500 feet. The quantitative laboratory has filter pumps to each desk. The physical laboratory is supplied with a lecture-room furnished with all modern appliances. Rooms are fitted up for those who desire to do special work in experimental physics. Lectures and the text-book are combined, illustrated by numerous experiments throughout the course. There is a very complete cabinet of philosophical apparatus; a large dynamo-electric machine, for producing powerful electric currents, can be used for producing the electric light, as a motor for driving machinery, or to illustrate all the effects and uses of electricity. An electric engine in the college workshop is of sufficient power to drive sewing-machines and other pieces of light apparatus, and was planned and constructed by a post-graduate student. The laboratory has an excellent galvanometer and set of resistance coils, so that good work can be done in the way of electrical measurements.

The zoölogical museum includes mounted specimens of a few mammals, several hundred birds (mounted), representing the *avian fauna* of the State, a large collection of reptiles in alcohol, a few fishes, and a small but typical collection of invertebrates. A set of the "Ward models," illustrating the principal larger fossils, is of service in this study, as well as in geology. There are besides the following collections in process of formation: an entomological cabinet, sets of the eggs and nests of birds, the brains of vertebrates, skulls of mammals, and skeletons of vertebrates. The museum is used during part of the year as a laboratory.

The geological museum possesses a good collection of the common rocks and minerals to which the student has access. Among other advantages for pursuing this study, the museum contains a set of the Ward series of geological casts.

A horticultural laboratory and green-house occupy separate buildings. The botanical collections, now rapidly increasing, are made mainly by students. There is a vegetable garden of 10 acres and experimental orchards occupying 20 acres; also a farm of 860 acres, with the various breeds of cattle, swine, and sheep, all supplied with the requisite stabling. An experimental farm of 30 acres is taken from this, wherein new varieties of grains, roots, grasses, etc., are tested.

The college buildings consist of main structure, boarding cottage, chemical and physical hall, horticultural building, south hall (used as boarding-house and for the college of domestic economy), the farm-house, creamery, workshop, laundry, and gas works. The workshops embraced for some time a printing-office, with steam-press, jobber, type, and all necessary fittings; and still include a shop for working in wood and one for iron work. The machinery is run by steam, and there is a good equipment.

KANSAS.

THE KANSAS STATE AGRICULTURAL COLLEGE.

[Statement by the president.]

OCTOBER, 1882.

This institution, located at Manhattan, Riley County, Kansas, was organized originally as Blue-Mont College, under the auspices of the M. E. Church; but upon Kansas receiving the national grant of 30,000 acres of land for each of its three members of Congress, the new three-story college building, completed in 1863, with 100 acres of land, was presented to the State and endowed with the 82,313.35 acres of land received under the act of July 2, 1862.

For ten years the management of the college remained essentially with the original founders, Rev. J. Denison, president, and it retained largely the character of a classical college and preparatory school, for which it had been designed.

The State had loaned funds for current expenses till the endowment should become

productive, and in 1870 provided that these funds, amounting to over $30,000, should be repaid, as soon as the income became sufficient to warrant it, by investment in permanent improvements. An issue of scrip in anticipation of expected surplus income procured the purchase of a fine farm of 155 acres, and the erection, at a cost of $11,000, of one wing of a huge barn.

In 1873 the organic law of the college was revised, a new board of regents appointed, and a new president, Rev. J. A. Anderson, selected, since which time the college has been maintained upon a thoroughly industrial basis, in that all students are required to learn the elements of some industry, while the course has been modified from time to time to correspond, by excluding the classics and including more complete instruction in the sciences related to agriculture and the mechanic arts.

In 1875 the erection of buildings upon the new farm was begun, and the "barn" was made the principal college building, leaving the old college, one mile distant, to serve as a dormitory, so that the principal part of its growth, as now existing, has been within the last eight years, more than half of which were years of struggle against local opposition and with poverty, debt, and general lack of comfort or convenience. Five substantial buildings had been provided at a cost of $35,000, and considerable improvement upon the farm had been made, when, in 1879, President Anderson resigned to take a seat in Congress, and the present president, George T. Fairchild, who had been fifteen years a professor in the Michigan State Agricultural College, was chosen.

The college has now, October, 1882, a productive endowment of $386,164.87 invested in school and municipal bonds at an average interest of 8 per cent., received wholly from the sale of 69,723.15 acres of the original land grant. There remains to be sold 12,590.37 acres, rapidly selling at an average price of nearly $8 an acre, and the State still claims from the national government 7,686.47 acres deficiency in the lands patented to the State under the act of 1862.

The income for the last financial year, closing June 30, 1882, was $28,890.76, of which $25,779.82 was from interest upon the invested endowment; the rest was from rent, fees, and sales of stock. The expenses during the same year for all college purposes were $24,701.42. The year closed with a balance in the treasury of cash $10,969.23, and uncollected interest overdue, $6,461.37. There were unexpended balances of appropriations for library and other specific purposes of $1,276.92. These particulars of the financial condition are given to show how fully this State has met the requirements of the act of 1862, in making the fund as large as possible and in guarding it from loss, and to emphasize the prosperity of the past three years, during which the income has increased from $18,000 to nearly $29,000.

The college has received from the State for all purposes, besides the mileage and fees of regents and commission of land agent, $212,482.02, $77,000 of which has been for the buildings now in use. These, all of the famous Manhattan limestone, stand upon a sightly elevation, overlooking the city and giving a fine view of the most beautiful part of the Kansas valley. The principal building, or college hall, yet incomplete, contains now a chapel to seat six hundred people, society room, offices, library, reading room, and class rooms for agriculture, mathematics, English history, and drawing. When fully completed the building will be 130 by 250 feet in extreme dimensions, arranged in three different structures, with connecting corridors. The other buildings answer the following description: Chemical laboratory, one story high, 36 by 99 and 46 by 75 feet, in the form of a cross. It contains eight rooms, occupied by the department of chemistry, physics, and mineralogy, and the printing office.

Mechanics' Hall, 39 by 103 feet, of two stories, occupied by the carpenter shop and finishing room, telegraph office, sewing rooms, music rooms, and kitchen laboratory.

Horticultural Hall, 32 by 80 feet, one story and cellar, with cabinet room, class room, work room and storage, with small greenhouse attached.

Armory Hall, 46 by 96 feet, and two stories high. It was originally designed for a barn, and once served as the chief building of the college, but is now used for the armory and drill room, the dwelling of the farm superintendent, and rooms for the janitor and a few students.

The barn, of stone, 48 by 96 feet, with side-hill basement stables, granary, tool room, &c.

The piggery, of wood, contains six pens, with yards attached.

A farm house, purchased with the farm, is still occupied as the president's house. The original college buildings, a three-story hall and a dormitory, are but partially occupied on account of the distance from the principal work and machinery.

Both farms are surrounded by substantial stone wall, and both have considerable plantations of forest, fruit, and ornamental trees.

The total property of the college is inventoried at a trifle over $125,000. This includes, besides the buildings above mentioned, various means of illustration and instruction, as follows:

Two farms of 171 and 100 acres. Eighty-five acres in crops; 30 acres in tame grasses;

81 acres in prairie pasture and mowing land of native grasses. Samples of special crops and experimental plots in grains, grasses, and forage crops.

A well planned barn for grain, hay, horses, and cattle; and a piggery with ten pens, with separate yards.

Shorthorn, Jersey, Polled Angus or Aberdeen, and Galloway cattle, Berkshire and Essex swine.

Farm implements of approved patterns.

Orchards, containing apples, peaches, pears, plums, cherries and apricots, of many varieties.

Small-fruit garden, with varieties of blackberries, raspberries, gooseberries, currants, and strawberries; and vineyard with fifty varieties of grapes.

Forest plantation of 5 acres, containing twenty varieties of trees of from ten to fifteen years' growth.

Ornamental grounds, set with a variety of evergreens and deciduous trees. Sample rows of ornamental and useful trees and shrubs, labeled.

Vegetable garden, with hot and cold frames and experimental beds. Practice rows for students' budding, grafting, cultivating, and pruning.

A small greenhouse, with collection of bedding and house plants. Chemical laboratory, with seven rooms, fitted with tables and apparatus for a class of forty students; also, physical apparatus and meteorological instruments.

Mathematical instruments, models and patterns for drawing, and charts for illustration.

Cabinets of mineral and geological specimens, including the collections of Professor Mudge; and growing collections in botany, entomology, and zoölogy, with some interesting illustrations in ethnology.

Collections of grains, grasses, and forage plants, and of native and foreign woods.

Carpenter shop, with separate benches and tools for twenty students in each class, besides lathe, mortising machine, scroll saws, and general chest of tools for fine work.

Shop for iron work, with forges, vises, drill, &c.

Printing office, with twenty-five pairs of cases, a good assortment of type, and a half-medium Gordon press,

Telegraph office, with six miles of line, connecting thirty-two branch offices and as many instruments.

Sewing rooms, with five machines, models and patterns.

Kitchen laboratory, with range, cooking and table utensils, dining-room furniture, and dairy apparatus.

Music rooms, with three pianos, an organ, and other instruments.

Library and reading room, containing over 3,600 volumes and 150 periodicals, to which all students have access during college hours.

Armory, containing seventy-five stand of arms (breech-loading cadet rifles, caliber 45) with accouterments.

The course of study, essentially the same to all classes of students, except for variations in industrial training requires four years of training in English and the natural sciences with applications in agriture, horticulture, mechanics and domestic arts. Students are admitted upon examination in the elements of common school studies and pursue their studies in the following order:

First year.—Fall term: Arithmetic, English analysis, geometrical drawing. Winter term: Book-keeping, English structure, United States history. Spring term: Algebra, English composition, botany with drawing.

Second year.—Fall term: Algebra completed, elementary chemistry, horticulture, 14 lectures in military science. Winter term: geometry, practical agriculture, (household economy for ladies), organic chemistry and mineralogy, 12 lectures in military science. Spring term: Geometry completed, with drawing, entomology and anatomy, analytical chemistry.

Third year.—Fall term: Trigonometry and surveying, physiology, general history. Winter term: Mechanics, agricultural chemistry, rhetoric. Spring term: Civil engineering, with drawing, (hygiene for ladies), chemical physics, English literature.

Fourth year.—Fall term: Agriculture (literature for ladies), meteorology, psychology. Winter term: Logic (deductive and inductive), zoölogy, structural botany. Spring term: Geology, United States Constitution, political economy.

These studies are taught with especial reference to an accurate use of knowledge in every-day life, and a habit of keen and precise observation as students.

The scope of special studies is shown in the following outline:

PRACTICAL AGRICULTURE.—*Second Year.*—History of agriculture, showing the successive steps by which the art has attained its present position. History and characteristics of breeds; their adaptation to the varying conditions of soil, climate, and situation; study of the forms of animals as shown by the different breeds belonging to the college;

the relation of stock-raising to general farming. Cultivation of hoed crops; management of corn and roots with reference to stock-feeding and the growth of finer grains. The growth of the "tame grasses" in Kansas, the best sorts for the State, and their management as shown by experience on the college farm and elsewhere. Implements of simple tillage; mechanical principles involved in their construction. Application of labor. Draught; different adjustment as affecting draught. Use of the dynamometer. Plows for soil and sub-soil. Drainage; soils that need draining; how to lay out a system of drains. *Fourth Year.*—General principles governing the development of domestic animals. The laws of hereditary disease; of normal, abnormal and acquired characters; atavism; correlation in the development of parts; in-and-in breeding and cross-breeding; influences affecting fecundity. The selection and arrangement of the farm with reference to the system to be pursued. Rotation of crops; general advantages of a rotation; the best rotation for the distribution of labor, production of manure and extermination of weeds; planning farm buildings—barns, piggeries, and stables; manure—how best housed and applied; composting; commercial fertilizers. Agricultural experiments; field and feeding experiments. Stock-feeding and meat production; stall-feeding; soiling. In this Miles's Stock Breeding is supplemented by a course of lectures.

HORTICULTURE.—It is the aim to teach this art from a botanical basis. The student applies his knowledge of the prime facts in botanical physiology to the various operations of the nursery, orchard, and garden. Barry's Fruit Garden is used, supplemented by a series of lectures upon the following topics, among others: The scope of horticulture. General principles of propagation by buds, by seeds. Production of improved varieties, by careful selection of seeds, by interfertilization of known kinds. Pepetuation of valuable sorts of fruits by bud propagation, budding, grafting, layering, &c. The important points in nursery manipulation. The orchard, conditions of site, soil, exposure, elevation. Special treatment of different kinds of fruit trees. Pruning. Gathering and storing fruits. Small-fruit culture; lists of varieties suitable for Kansas planting. Vegetable garden; selection and preservation of seeds; planting and transplanting. The management of the hot-bed and cold-frame. Forest plantations. Wind breaks. Hedges. Trees and shrubs for ornamental purposes.

BOTANY.—During the course two terms are given to the study of botany.

Elementary botany.—In the first year the student is familiarized with the aims of botanical classification to a sufficient degree to enable him to appreciate differences and resemblances in the plant kingdom, and is made acquainted with the salient points in plant physiology. Gray's Manual and Lessons is the text-book.

Advanced or higher botany.—In the fourth year, the intimate structure of plants, a more detailed study of plant physiology (in the germination of seed, the growth of cellular substance, and the fertilization of the ovule), variation and improvement of varieties, parasitic fungus, are among the topics studied. The text-book used in this part of the course is Bessey's Botany. This study is made more practical by the use of the compound microscopes belonging to the department, of which there are fifteen, with suitable accessories for a high grade of work.

CHEMISTRY.—*Inorganic chemistry*, which occupies fourteen weeks in the second year, includes a consideration of chemical forces and of the laws of chemical combination, with nomenclature and formulæ, and a careful study of the history, manufacture, physical and physiological properties, tests and uses of the various elements and their compounds. Especial attention is given to those substances having extended application in the arts.

Organic chemistry comprises a six weeks' course of lectures upon the theory of organic types and compound radicals, and the preparation and properties of those organic substances most useful to man.

In *chemical analysis* each student has his stand in the qualitative laboratory, completely furnished with apparatus and chemicals for his own use. His work includes the analysis of more or less complex mixtures of chemicals, minerals, ores, soils, mineral waters, well waters, &c.

Agricultural chemistry.—This includes a thorough consideration of the application of chemical principles to the economy of the farm; the origin and formation of soils; the classification and composition of soils, the analysis of soils, and their adaptation to the purposes of production; the composition and use of manures; composting; chemistry of farm operations, such as plowing, fallowing, draining; chemistry of plant growth. Text-book, Johnson's How Crops Feed.

MINERALOGY AND GEOLOGY.—For six weeks in the second year, two hours a day are given to mineralogy. This includes the study of crystallography, with the properties, forms, and uses of the principal minerals of the United States. Blow-pipe analysis forms an important part of the course, each student being required to name and identify a large series of minerals.

A term's study in the fourth year gives a view of the causes which have produced the geologic changes in the past, of the general arrangement of the earth's crust, and of

special peculiarities of the various strata. Attention is given to the formation of soils and deposits of valuable minerals, especially in Kansas.

PHYSICS AND METEOROLOGY.—Two terms' work gives an opportunity for experimental study of the laws of light, heat, electricity and magnetism, the constitution of the atmosphere, the measurement of temperature and humidity, atmospheric pressure. This course also includes a careful study of instruments and methods employed in taking meteorological observations.

ANATOMY AND PHYSIOLOGY.—A full term's study is preceded by a course of lectures on anatomy. The study of physiology embraces a thorough consideration of the functions of the organs of the human body, and the relation these sustain to the conditions of health and disease. Among the topics discussed these may be mentioned: food and digestion; assimilation; secretion and excretion; the circulation of the blood; the nervous system; the special senses; reproduction.

SPECIAL HYGIENE.—To the ladies of the third year, a course of daily lectures is given by the lady superintendent of the sewing room upon the laws of life and health. The course extends over a period of ten weeks, and covers questions pertaining to personal health and the health of the household, such as food, air, exercise, clothing, temperature of rooms, &c.

ENTOMOLOGY.—This science is studied with especial reference to its economic relations with agriculture and horticulture. A brief course in the principles of classification is followed by a more extended study of the life history of beneficial and injurious insects and means of encouragement of one and control of the other.

ZOÖLOGY.—In this study Packard's Zoölogy has been adopted as the text-book. The intention of the course is to familiarize the student with the characters of some type of each class, and then by comparative study with the chief modifications of the type chosen. Especial attention is directed to comparative anatomy and physiology, as underlying all logical classification.

HOUSEHOLD ECONOMY.—A series of lectures to the ladies of the second year class, accompanied by practical illustration in the kitchen laboratory, continues through a term of twelve weeks. These cover the general ground of economical provision for the household, marketing, cooking, preserving, order, neatness, and beauty in table service, comfort in the family, and care of a sick-room.

SPECIAL COURSES.—Persons of suitable age and advancement who desire to pursue such branches of study as are most directly related to agriculture or other industries may select such studies, under advice of the faculty. Assaying and pharmaceutical chemistry may be provided for by special arrangement when students are qualified to pursue them.

POST GRADUATE COURSES.—Arrangements can be made for advanced study in the several departments at any time. Special opportunities for investigation and research will be afforded to resident graduates.

All other branches of study are so taught as to give most thorough work in the time allotted to them.

INDUSTRIAL ARTS.—The training in these departments is designed to be systematic and complete in each, so that any student following a single line diligently through a four years' course gains the essentials of a trade and a reasonable degree of skill. Those who wish only a general acquaintance with the arts can take shorter courses in several of them; but all are to select with definite purpose. All are required to give at least five hours a week to some course of training, and most of these are so adjusted as to occupy a single hour each day in the regular routine of classes; a few take two and a half hours in the afternoon of two days each week.

Young ladies are required to give the necessary time for practice in the kitchen laboratory, and are expected to show some facility in the practice of the sewing room, though other industrials may occupy their course.

DAIRYING.—During the spring term daily instruction and practice in the different branches of dairying is given the young ladies of the second year by the professor of agriculture in a dairy well equipped with improved appliances for the manufacture of butter and cheese. The course of instruction given on this subject embraces the following cognate subjects: Dairy products as human food; influences affecting the quantity and quality of milk; the factory system, and household plans of cheese making; butter making; creameries; "deep and shallow" setting systems; packing and preserving butter. This instruction is enforced by regular and systematic work in the dairy.

Work in the farm and gardens is required of young men during one term of the second year and one term of the third year. Every young man thus gains acquaintance with the methods of the college and with the work itself.

CARPENTRY, &C.—On entering the shops all are enrolled as carpenters, and take the same first lessons in sawing. planing, and dressing lumber, making mortises, tenons, and joints, and in general use and care of tools. Later, one who chooses a trade is provided with work in the line chosen; while the farmer's course provides for general training in

a great variety of operations, rather for ingenuity than for skill. In the full course of a carpenter, special instructions are given in the whole range of work, from framing to stair-building. Students are allowed, after attaining sufficient skill, to work upon their own materials, under the advice of the superintendent. All are required to take at least one term of practice in the shop during the first year at college. In iron work, instruction is given in ordinary forging, filing, tempering, &c.

PRINTING.—Two courses are pursued in this art. In one the student is taught the implements or tools employed in typography and how to use them; composition, imposition, correcting proof, technical terms, presses and their workings, and the general duties of a first-class workman. The second course of lessons alternates with those in the first, and embraces instruction in spelling, capitalization, syllabication, punctuation, proof-reading, preparation and criticism of essays, and such other work as will make the student accurate and expert in language. *The Industrialist*, a weekly paper edited by the faculty as an exponent of the work of the college, is printed by the students in the department.

TELEGRAPHY.—The course of training involves for beginners the characters that compose the alphabet and combinations of these characters into words and sentences—attention being paid to spelling and to short and precise expression in messages—abbreviations, signals, forms of messages, train orders, reports, &c. To the more advanced is given regular line business, as press reports, messages, cipher messages, and orders in all forms used by prominent telegraph companies, together with the necessary book-keeping on exact copies of the blanks in actual use, thus giving the student an understanding of the work of an operator. A portion of the time is devoted to instruction in the use and management of lines, batteries, instruments, &c. The elementary principles of electricity, magnetism, and electro-magnetism evolved in telegraphy are taught and illustrated by experiments. The more recent inventions relating to the art are discussed and explained. Pope's Hand-book of the Telegraph is used as a text-book.

SEWING.—Young ladies are taught in all ordinary forms of sewing with needle and machine and in cutting, fitting, and trimming dresses and other garments.

MUSIC.—Provision is made for the teaching of instrumental music. The college furnishes instruments for daily practice, but the teacher depends upon his fees for income. Instruction in vocal music for beginners and for advanced students is furnished at a very slight expense.

MILITARY TRAINING.—During the second year a course of twenty-six lectures is given. These are designed to show what an army is for, its relation to the country, and, in a general way, to describe its organization and duties. To those who desire it an opportunity is given to obtain a fair practice in the ordinary infantry drills, including bayonet exercise. Although drill is thus made optional, students are not allowed to take it for periods shorter than one term.

Classes are in session from 9 a. m. to 1 p. m. of every week day except Saturday, and no student may be absent without excuse. A full and permanent record of attendance, scholarship, and deportment shows to each student his standing in the college, and after each monthly examination a report of advancement is made to parents. Chapel exercises occupy fifteen minutes before the meeting of classes each morning, and unnecessary absence from them is noted in the grades.

Twice in each month the whole body of students gather for a lecture from some member of the faculty, or for the rhetorical exercises of the third and fourth year classes. On alternate weeks all the classes meet at the same hour in separate class rooms for exercise in elocution and correct expression.

LABOR.—The general drift of instruction and training is such as to encourage habits of manual labor during the course. The work of the college is done chiefly by students at wages ranging from eight to ten cents per hour, and every effort is made to encourage those who depend largely upon their own earnings for an education. The amount paid to students for labor during the last year was $1,611.70.

Expenses of students are at the same time limited by the general economy of surroundings. Tuition is free except in music; to young men in telegraphy and in printing for the first year, and to all in analytical chemistry a small fee each term is charged to cover incidental expenses.

Of the students attending the college 75 per cent. are from farmers' homes, and a very large proportion of the rest from the families of mechanics and tradesmen.

Since the organization in 1863, there have been in attendance 2,072 different students—1,369 male and 703 female.

The attendance of the last college year was 312 (224 male and 88 female). The average age this year was 19.35 years, and the students were gathered from 54 counties of Kansas and from 13 other States. The present year shows an increase of 40 over the attendance of last year at this date, and a better preparation for the course.

The graduates of the college number 74 (46 male and 28 female). Twenty-four of these

received the degree of A. B., and 50 that of B. S. Seven have taken a second degree in course.

The general influence of graduates and students of shorter course is widely felt in the general improvement of the State in all departments of industry.

The college is now under the control of a board of regents, 6 in number, appointed by the governor of the State, subject to the approval of the State senate, and commissioned for a term of three years. All interests of the college, including the sale of lands and care and investment of funds, are committed to their charge. The president of the college, elected by the board, becomes *ex officio* a member of that body.

The faculty is composed of the president, professors, and superintendents regularly appointed by the board; and all methods of instruction and discipline within the prescribed course are intrusted to their direction. This body has now 14 members, employed at salaries ranging from $600 to $2,200, and amounting to $14,800 a year. The members are as follows: President and professor of logic and political economy, professor of mathematics and engineering, professor of practical agriculture and superintendent of the farm, professor of chemistry and physics, professor of botany and zoölogy and superintendent of the orchards and gardens, professor of elementary English and mathematics, professor of military science and tactics detailed by United States War Department, instructor in English and history, instructor in industrial drawing, superintendent of telegraphy, superintendent of printing, superintendent of sewing and instructor in hygiene and domestic economy, superintendent of workshops, teacher of music.

Besides the work of instructing the youth of the State who gather at the college, the faculty have undertaken various experimental researches of direct interest in agriculture and other industries. The results have been disseminated through the columns of The Industrialist, a weekly paper edited by the faculty and widely circulated, and by publication of official reports. Recently a series of farmers' institutes has been organized to reach and co-operate with the farmers of different sections of the State. These have proved efficient means of advancing the interests of both the college and agriculture throughout the State.

Members of the faculty are prominent in the various educational associations of the State, as well as those for the promotion of agriculture, horticulture, and science in general. The college is generally recognized throughout the State as serving well the purposes of the national land grant and working out profitably the problem of industrial training with a liberal education, though, as yet, only an encouraging beginning has been made.

The improved facilities and extended means of the immediate future must help to more complete success and larger usefulness in the same direction.

GEO. T. FAIRCHILD, *President.*

KENTUCKY.

AGRICULTURAL AND MECHANICAL COLLEGE OF KENTUCKY.

OBJECTS.

The leading aim of this college is to teach the branches that are related to agriculture and the mechanic arts. During our connection with Kentucky University, which existed from 1866 to 1878, but little success was attained in that direction. This was due to the failure of Kentucky University to meet the obligations it had contracted.

In 1878 the State of Kentucky detached this college from Kentucky University and by action of the legislature it was placed upon an independent footing. The State has added a classical to the former course of scientific study, and also a normal school department. The preparatory department of the college works in connection with and subordinate to the normal school department.

INCOME AND EXPENDITURE.

The annual income is $9,900 from the Congressional land fund of 1862, $16,000 from tax levied by the State for the benefit of the college, $2,500 from tuition fees; total, about $28,400.

THE FACULTY.

The faculty consists of the president, who is also professor of civil history and metaphysics, professors of mathematics and astronomy, natural history, Latin and Greek,

French and German, chemistry and physics, English language and literature, and a principal of the normal department (with three assistants), practical mechanics, and military tactics.

STUDENTS.

There were last year (1881–'82) 320 students in the college, of whom 249 were males and 71 females. Last year there were six graduates. The whole number of graduates since 1878 is fifteen. Women have access to all the classes of the institution. Each legislature representative district is entitled to send *four* properly prepared students free of tuition, and each county four normal school pupils.

THE COURSE OF STUDY.

The time given studies is as follows: history, two years; mental and moral philosophy, one year; mathematics (exclusive of preparatory), four years; Latin and Greek, four; chemistry and physics, two; natural history, four; English language, four; French and German, each, two; normal school, three; bookkeeping course, two; tactics and military science, two. Instruction is mainly from text books.

SCHOOLS AND STUDIES.

The instruction is classified, according to its nature, into schools, as follows:

1. School of civil history, embracing studies in European history, that of the United States, Germany, England, the constitutions of the United States and of England, and political economy.
2. School of English language and literature, with an excellent course.
3. School of mental and moral philosophy.
4. School of mathematics, covering algebra, geometry, trigonometry (plane and spherical), analytical geometry, calculus, mathematical physics, and astronomy.
5. School of chemistry, embracing elementary physics, practical chemistry, with application to agriculture, mechanic arts, and medicines; there are lectures and laboratory illustrations.
6. School of natural history, embracing physical geography, botany (general and economic), anatomy and physiology, forestry, zoölogy, microscopy, geology, and palæontology.
7. School of modern language, embracing French, German, Spanish, and Italian.
8. School of military tactics and civil engineering.

A normal department has been added by the State, and it is proposed to endow a professorship of the "theory and practice of teaching."

The technical value of the institution has been enlarged by an advanced course on agricultural chemistry; by special lectures on the relation of geology to soils, of forests to agriculture, and of insects to vegetation.

There is an evident desire to increase the efficiency of the college in every branch of instruction.

The grounds upon which the college buildings are situated were given by the city of Lexington to secure the location of the college, and comprise 52 acres within the city limits. The bulk of the money expended in the erection of buildings was given by the city and county of Fayette. The estimated value of the grounds is $25,000, and of the buildings, $85,000.

President Patterson adds also the following:

HISTORY OF THE COLLEGE.

The proceeds of the land grant were first applied to the creation and maintenance of an agricultural and mechanical college of the Kentucky University, a denominational institution. When this college was detached from its former connection in 1878 a commission was appointed to determine its future character and location. After a provisional existence for two years the legislature of 1879–'80, in accordance with the recommendation of the commission, established it upon the grounds offered to the State by the city of Lexington. After a long contest the legislature also agreed to give the college the proceeds of a tax of one-half cent on each hundred dollars of taxable property in the Commonwealth, said tax to continue until repealed. The principal opposition to this additional endowment came from friends of the Kentucky University, who fancied that their institution would be injured by the establishment and success of the State college.

A board of trustees was appointed, nominated by the governor, and confirmed by the senate, and the college was by them reorganized in accordance with the terms of the charter on a basis entirely undenominational.

The success of the first year under its reorganization more than exceeded expectations.

But when the legislature of 1881–'82 met the college found itself forced into a struggle for existence. All the denominational colleges of the State, Presbyterian, Baptist, Methodist, and Christian, formed a combination to procure the repeal of the one-half cent tax voted by the preceding legislature for its aid. Their chief ground of complaint was that the State college because of the aid secured by the State was making education so cheap and so comprehensive that they were unable to compete with it. After a contest of nearly three months, in which all the resources and menaces of ecclesiasticism were evoked and used, the bill for repeal was laid on the table of the house of representatives by a vote of 51 to 38. The contest is, however, not yet ended. The presidents of the aggrieved colleges have carried the question of the constitutionality of the tax into the courts, where it is now pending.

If let alone the State college will do a good work and supply a want long felt in Kentucky.

LOUISIANA.

State University and Agricultural and Mechanical College

The institution which is now receiving the income of the fund arising from the national land grant made to Louisiana for the establishment of an agricultural college is the result of combining the old State university and the Agricultural and Mechanical College. The State university was founded in 1853, and opened at Alexandria in 1860, under the superintendence of General (then Colonel) W T. Sherman. In 1869 its building was burned, and the institution moved to Baton Rouge. In 1877 the Agricultural College, which had been in operation in New Orleans since its opening in 1874, was made a part of the university.

The object of uniting the institutions was to provide a seat of learning where literature, science, and the arts should be taught, and where the citizens should be fitted "to perform skillfully and magnanimously all the offices, both private and public, of peace and war." To carry out its object the law requires it to provide "general instruction and education in all the departments of literature, science, art, and industrial and professional pursuits," and "special instruction for the professions of agriculture, the mechanic arts, mining, military science and art, civil engineering, law, medicine, commerce, and navigation."

The productive funds of the institution are $318,313. Two sources from which they have been obtained have been the seminary fund, which had its origin in grants of land made by the general government in 1806 and 1811, and the agricultural college fund, which was originally $327,000. It was reduced in 1875 to $196,200. The income of these funds is about $14,500. An annual State appropriation of $10,000 nominally makes up the entire income to an amount sufficient to enable the university to carry on efficiently the work which has been assigned to it by State legislation. But the $10,000 appropriated have realized to the university a sum much less, the net value of it being $6,700 in 1880 and in 1881, though the outlook for the present year is more favorable. Nothing is derived from fees toward the support of the institution, as tuition is free to all.

There are 8 professors and 159 students. The work of both is being performed thoroughly and satisfactorily. The full courses in agriculture and the mechanic arts cover three years each of undergraduate study. The subjects pursued are arranged for the purpose of educating those who propose to devote themselves to agriculture and the industrial arts in Louisiana. It is considered as presenting an opportunity nowhere else to be had for intelligent training in the cultivation of the semi-tropical staples, sugar, cotton, and rice. Special studies are added in horticulture and the domestic arts.

The college maintains no extensive laboratories or costly farm, but utilizes the practical opportunities for study found in the cotton fields and gin-houses, the sugar plantations and mills, the rice fields, oil mills, &c., which are open for study and investigation around Baton Rouge.

The agricultural course embraces French, chemistry, physics (including the theory of the steam engine), animal and vegetable physiology and anatomy, with scientific agriculture and rural economy, and engineering. These latter include farm architecture, hygiene, veterinary surgery, surveying roads, bridges, levees, ditches, &c. There are also added short courses of social and industrial history, English rhetoric and literature, bookkeeping, political economy, and ethics. One hour a day is devoted to labor in the field, garden, or workshop.

In the mechanical course the instruction is full, both theoretical and practical. The studies embrace mathematics, analytical and descriptive geometry, a short course in engineering; also drawing, French, chemistry, physics, social and industrial history, and other

studies similar to those in the agricultural course. The workshop has (1880–'81) been opened, and contains tools, engine, lathes, forge, &c., to illustrate and teach both wood and iron working. It has proved both useful and successful, and has enlisted the public interest largely.

Students in the Agricultural and Mechanical College have access to the cabinets, collections, and chemical and physical apparatus, but the chief design of the instruction pursued is to familiarize students with the practical knowledge grounded on the sciences underlying industrial occupations.

The State topographical survey was made under the general direction of the university.

The attention devoted to the sugar cane and other tropical staples makes the Louisiana State University and its agricultural instructors an authority, and it is the special aim of the faculty to steadily increase this usefulness.

A station for the production of vaccine lymph was established in February, 1882, and an apiary is suggested by the president as a proper addition to the practical appliances of the college.

The experiments and the actual work are carried on largely by the students, under the direction of the professor in charge, and thus the educational and scientific character of this branch of the college is brought into prominence. The vaccine establishment has been self-sustaining, besides gratuitously distributing more than 20,000 ivory points, with very satisfactory results, and has met the hearty approval of the physicians of the State.

Owing to its origin as a military academy, for a long time almost exclusively devoted to the education of State students, this institution is carried on under a strictly military system. The discipline is exact, though not severe, and all cadets drill one hour daily. The larger portion of the corps reside in the barracks, but a considerable number live with their parents or guardians in Baton Rouge, and under the same regulations as others from 8 a. m. until 5 p. m. This somewhat anomalous system is adapted to the needs of the students.

MAINE.

The State College of Agriculture and the Mechanic Arts.

[From special statement of the president and annual catalogues.]

"The object of the institution is to furnish to the young people of the State (those from other States not excluded) who may desire it the advantages of a thorough, liberal, and practical education, and especially instruction in such branches of learning as are related to agriculture and the mechanic arts."

ENDOWMENT AND FUNDS.

Its endowment, which is much too small for its purposes, was derived from the sale of land donated by the national government by act of Congress in 1862. The amount of land to which this State was entitled was 210,000 acres. By direction of the legislature of the State the land scrip was sold by the governor and council, and at a ruinously low figure, the price received for the greater part of it being but 53 cents per acre. As a result the endowment secured was less than $120,000. From interest which accumulated chiefly before the institution was opened to students, this sum was increased to $132,500, which is the present endowment. The larger part of this is invested in State 6 per cent. bonds, and has yielded a revenue of about $8,000 per annum.

Considering the low rates at which safe investments can now be made, the revenue from this source is estimated at $7,500.* For other assistance the institution is obliged to look to the State.

The annual expenditure is about $11,000; the annual expense of teaching force, $10,000. Several of the instructors recently entered upon duty at moderate salaries. With increasing efficiency of service their compensation must be increased. The prospective annual expense of teaching staff is $12,500, and the prospective ordinary annual expenditure, $14,000. These figures presuppose the maintenance of the institution on its present basis. Any considerable enlargement of plan would involve necessarily an increase of annual expenditure.

The value of grounds and buildings is $120,000; of library, apparatus, &c., $25,000.

* By direction of the State legislature, since August, 1881, a moderate tuition has been charged, yielding an annual revenue of something above $2,000.

The site was given by the towns of Orono and Oldtown, and cost $11,000. The buildings have been erected principally by means of appropriations made by the State. Citizens of Bangor contributed something over $12,000 for the benefit of the college in its early years.

THE FACULTY.

The number of instructors is nine (not including the farm superintendent, who gives no class room instruction), namely: President (who is professor of physics and mental and moral sciences), professor of chemistry, professor of civil engineering, professor of mechanical engineering, professor of natural history, professor of modern languages, professor of agriculture, instructor in vise work and forge work, and professor of military science, assigned by the United States Government.

STUDENTS AND GRADUATES.

The number of students in 1881–'82 was 90, 3 of whom were young women. No charge for tuition has been made until recently, except for students from without the State, who are charged the nominal sum of $12 per term. Tuition is now $30 a year. Only one scholarship has yet been provided; others are earnestly desired.

The number of graduates is 156, 140 young men and 16 young women. Of these, 50 have graduated in the course in civil engineering and 22 in mechanical engineering. Upon 84 has been conferred the degree of bachelor of science, which includes those who have taken the course in agriculture, in chemistry, and in literature and science. The course in science and literature is the course in agriculture with certain modifications adapting it more especially to the wants of young ladies.

Besides the 156 graduates, there have been connected with the institution for periods of time, ranging from one term to three and a half years, 210 students.* Of the 366 who have received training at the college the vocations of 250 are known. Of this number 27 per cent. are engaged in agricultural pursuits and 27 per cent. in the mechanic arts; 11 per cent. are in professional life and 89 per cent. are engaged in non-professional callings.

The graduates have been very successful in passing early to worthy and lucrative positions, and, so far as known, have maintained themselves with credit in the positions secured.

THE COURSE OF STUDY.

The plan of instruction embraces five courses of study, namely: A course in agriculture; a course in science and literature, which is the course in agriculture with certain modifications; a course in civil engineering; a course in mechanical engineering, and a course in chemistry. The subjects taught and the time given to each may be best understood by an examination of a condensed outline of the courses, together with brief explanatory statements.

COURSE IN AGRICULTURE.

For the first year the course embraces physical geography, physiology, algebra, rhetoric and botany, geometry, French, bookkeeping, and labor on farm.

For the second year it includes botany, horticulture and arboriculture, general and qualitative chemistry, physics, French, English literature and surveying or (L) history of England, trigonometry, freehand and mechanical drawing, field work and forge work (elective with a part of the mechanical drawing).

For the third year, it requires farm drainage, mechanical cultivation of the soil and physics, agriculture and organic chemistry with principles of plant feeding, mechanics, agricultural engineering and farm implements, zoölogy and entomology, German, laboratory work and experimental farming, or analysis of English authors (elective).

For the fourth year are required landscape gardening, stock breeding, and veterinary science, cultivation of cereals, care and feeding of animals, dairy farming and sheep husbandry, comparative anatomy, mineralogy and geology, history of civilization, United States Constitution and political economy, logic, mental and moral science, with experimental farming and agricultural botany or historical readings and analysis (elective).

COURSE IN CHEMISTRY.

For the first year the following studies are included: Physical geography, physiology, algebra, rhetoric and botany, geometry, French, bookkeeping, and labor on farm.

For the second year: General and qualitative chemistry, botany, horticulture and arboriculture, physics, French, English literature, surveying, trigonometry, freehand and mechanical drawing with field work.

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* Not including those now in the college.

For the third year: Chemistry, physics, German, zoölogy and entomology, American literature, laboratory work.

For the fourth year: Chemistry, comparative anatomy, mineralogy and geology, history of civilization, United States Constitution and political economy, laboratory work, logic.

COURSE IN CIVIL ENGINEERING.

For the first year the following studies are included: Physical geography, physiology, algebra and geometry, rhetoric and botany, French, bookkeeping, and labor on farm.

For the second year: Trigonometry, botany, horticulture and arboriculture, general chemistry, analytical geometry and calculus, English literature, surveying, physics, French, freehand and mechanical drawing, with field work.

For the third year: Henck's Field Book, mechanics, calculus, descriptive geometry, physics, descriptive astronomy, German, field work and drawing, isometric and cabinet projection and perspective.

For the fourth year: Civil engineering, designs and specifications, stereotomy, practical astronomy, mineralogy and geology, logic, United States Constitution and political economy, topography and railroad work, machine drawing and designing.

COURSE IN MECHANICAL ENGINEERING.

For the first year the following studies are included: Algebra and geometry, physiology, physical geography, rhetoric and botany, French, bookkeeping, and labor on farm.

For the second year: Trigonometry, analytical geometry and calculus, French, English literature and surveying, general chemistry, physics, botany, horticulture and arboriculture, free hand and mechanical drawing, field work and forge work.

For the third year: Machinery and mill work, calculus, descriptive geometry, German, shop work and machine drawing, isometric and cabinet projection and perspective.

For the fourth year: Hydraulic motors, steam engine, designs and specifications, practical astronomy, mineralogy and geology, logic, United States Constitution and political economy, applied descriptive geometry, machine drawing and designing.

THE AGRICULTURAL INSTRUCTION.

Instruction is given largely by lectures, and embraces the subjects of most marked importance to the farmer. The following defines the leading topics: Mechanics and farm implements, embodying use and principles of construction; agricultural engineering, roads, culverts, masonry, strength of materials; mechanical cultivation of the soil; principles of plant feeding; landscape gardening; cultivation of cereals; care and feeding of animals; dairy farming; sheep husbandry; botany, horticulture, arboriculture; chemistry; zoölogy and entomology, with bee keeping; comparative anatomy, including illustrated lectures on stock feeding and veterinary science; mineralogy and geology; law, international and rural.

INSTRUCTION IN SCIENCE AND LITERATURE.

The course in science and literature includes French and German, the general mathematical and most of the scientific studies of the agricultural course. Instead of certain branches quite purely technical in the latter course, history and English and American literature are substituted.

WOMEN STUDENTS.

In the special laws of the State, passed in 1872, it is provided that young ladies, "who possess suitable qualifications for admission to the several classes may be admitted as students in the college." In arranging the course in science and literature, reference has been had to this enactment. From this course, however, young men who desire it are not excluded, as, on the other hand, young ladies are not excluded from any of the other courses.

INSTRUCTION OF THE CIVIL ENGINEER.

The object is to give the student a thorough knowledge of higher mathematics, mechanics, astronomy and drawing, and at the same time a thorough drill in the use of instruments and in the application of mathematical principles and rules, so that the graduate can at once be made useful in engineering work, and be fitted after a limited amount of experience in the field to fill positions of importance and trust. The course is also arranged so as to afford the education required to prepare the graduate for a responsible position among *men* as well as among engineers.

In the first term of the third year, Henck's Field Book is used as a text book, from

which the student obtains methods of running railroad curves, calculations of earth-work, &c. This is supplemented by many examples, worked by the student, and by lectures on preliminary and final surveys and on the resistance to trains offered by curves and grades.

The subject of mechanics is taken up the last term of this year, in which the students receive a thorough training in the principles underlying construction, illustrated as far as may be by practical examples, in which these principles are applied.

Most of the time is given to statics, as being the branch of mechanics most applicable to civil engineering, enough of dynamics being taught to meet the requirements of the civil engineer. During the senior year Rankine's Civil Engineering is the text book, though other works are used for reference.

The course of study is thorough and practical, applied directly to materials and their use, together with engineering problems. Drawing is made a permanent and marked feature of every term. Field work in surveying, general, road, and railroad engineering, with topographical surveying, are its main features. Mineralogy, geology, and astronomy are carefully taught.

INSTRUCTION OF THE MECHANICAL ENGINEER.

It is the design of this course to give such a knowledge of mathematics, mechanics, principles of mechanism, drawing, and manual art, as shall enable the student successfully to enter practical life as an engineer with the same thorough education in subjects required to fit him for the general duties of life as is afforded by the other courses.

The work of the first two years is similar to that of the civil engineer's course, except that forge work is added in the second year.

There are now two shops equipped according to the Russian system, and work in these is required of all students in this course.

In the second term of the sophomore year, a course in forge work is given, in which the student becomes familiar with the methods in use in actual construction. A similar course in vise work is given during the first term of the junior year, in which a corresponding knowledge is obtained. It is the intention to add more shops at the earliest possible moment. It should be understood that it is the object in these shops to teach operations in use in a number of trades, rather than the details of any one trade.

INSTRUCTION OF THE CHEMIST.

This course aims to supply a want felt by students who wish to enter certain industries in which a somewhat extensive knowledge of chemistry is important. The first two years are mainly like those of the other courses, qualitative analysis being, however, obligatory for these students in the second term of the sophomore year.

During the junior year, daily recitations are held in agricultural chemistry and elementary organic chemistry, and the study of advanced inorganic chemistry is begun. In the senior year, advanced inorganic chemistry is concluded and advanced organic chemistry is taken up.

The afternoons are devoted to quantitative chemical analysis by the junior and senior students of the course. The work consists of the most useful gravimetric and volumetric methods, beginning with simple estimations, which are followed by more complex analyses of alloys, minerals, fertilizers, farm products, &c. A short course in the assay of gold and silver is also given.

DEGREES.

In the courses in agriculture, science and literature, and chemistry the degree of bachelor of science is given.

In the engineering courses the degrees are bachelor of civil engineering and bachelor of mechanical engineering. The master's degree in any of the courses may be conferred after three years.

LABOR.

It is a peculiarity of the college that it makes provision for labor, thus combining practice with theory, manual labor with scientific culture. The maximum time of required labor is three hours a day for five days in the week.

In the lowest class the students are required to work on the farm, and they receive compensation for their labor according to their industry, faithfulness and efficiency, the educational character of the labor being also taken into account. The maximum price paid is 10 cents an hour. The labor is designed to be as much as possible educational, so that every student may become familiar with all the forms of labor upon the farm and in the garden.

The students of the three upper classes carry on their principal labor in the laboratory, the drawing rooms, the work shops, or in the field; and for it they receive no pecuniary consideration, since this labor is of a purely educational character.

MILITARY INSTRUCTION.

Thorough instruction in military science is given by an officer detailed by the Secretary of War from the active list, United States Army.

All able-bodied male students receive instruction in the school of the soldier, company, and battalion drill.

Artillery drill is limited to the senior class.

Arms and equipments are furnished by the United States Government.

FARM AND BUILDINGS.

The college farm contains 370 acres of land of high natural productiveness and of great diversity of soil, and is therefore well adapted to the experimental purposes of the institution.

White Hall, the building first erected, affords excellent accommodations for a limited number of students. The lower rooms of this building are appropriated to general and class purposes.

Brick Hall contains 48 rooms and has connected with it a boarding house for students. In these buildings the institution furnishes desirable accommodations for 125 students.

The laboratory contains two apparatus rooms, a lecture room, a cabinet, a library and weighing-room, a recitation room, and rooms for analytical and other purposes, and is in all respects admirably adapted to the wants of the chemical and mineralogical departments.

APPARATUS.

The college is furnished with new and valuable apparatus for the departments of physical geography, chemistry, physics, surveying, civil engineering, and mechanical engineering, to which additions will be made as the exigencies of the several departments require. Models have been obtained from the United States Patent Office and others have been purchased that serve for purposes of instruction.

LIBRARY.

The library contains above 4,000 volumes, some of which have been obtained by purchase, while others have been kindly given to the college. The volumes secured through the liberality of Ex-Governor Coburn and the gifts of other friends are a valuable addition to this department. It is earnestly hoped that so important an auxiliary in the education of students in the college will not be disregarded by the people of the State, and that liberal contributions will be made to the library, not only of agricultural and scientific works, but also of those profitable to the general reader.

CABINET.

Rooms have been fitted up with cases of minerals and specimens of natural history, and several hundred specimens have been presented to the college. The valuable private cabinets of Prof. C. H. Fernald and Ex-President C. F. Allen are placed in these rooms and are accessible to the students. All specimens presented will be properly credited and placed on exhibition. Rocks illustrating the different geological formations and minerals found within the State are particularly solicited.

MARYLAND.

MARYLAND AGRICULTURAL COLLEGE.

[Statement of the president, 1880.]

The leading object of the Maryland Agricultural College is to promote agricultural education under the resolution of Congress of 1862.

ENDOWMENT AND FUNDS.

The United States land scrip invested by the State yields annually $6,978; the State gives annually, $6,000* additional; the grounds, buildings, and apparatus are estimated at

* The State withdrew the donation of $6,000 at the last session of the legislature.

$100,000, one-half owned by the State. Students from the State and District of Columbia, in consideration of the above yearly endowment, are admitted free of tuition. The only other income is from board, which at $200 a year yields an average income of $12,000. The annual expenditures, including repairs, improvements, and necessary working expenses, cover the whole income; the annual expense of teaching staff is $8,500.*

THE FACULTY.

The instructors and lecturers occupy the following chairs: President and professor of engineering and astronomy; registrar and professor of physics; professor of English literature, mental science, and history; of ancient and modern languages; of agriculture and natural history, architecture, &c.; of chemistry, and the instructor in military science.

STUDENTS' FEES—DEGREES.

For the last five years the students have averaged 75, all males. Students pay, in addition to a board bill of $200, $75 a year for tuition. There are no scholarships. Since 1875 there have been 20 graduates. During the war the college was closed.

The degrees conferred are bachelor of arts, bachelor of science, master of arts, and bachelor of agricultural science. Graduates are devoting themselves mostly to teaching and to agricultural pursuits. Nearly 1,400 students have registered since the college was founded.

Women are not admitted to any of the departments, since military instruction is one of the requirements of the government.

THE PLAN OF STUDY.

The course of instruction extends over four years, embracing all subjects under the chairs enumerated. The plan of instruction is by a systematic series of recitations, each one hour in length, accompanied by oral lectures and reviews. All the departments run through the four years.

APPLIANCES AND APPARATUS.

The theoretical outfit of the department of agriculture is complete, embracing all necessary charts, anatomical exhibits, seeds, minerals, and text books. There have never been sufficient appropriations for workshops. The laboratory is in good working order, and students are required to work four hours a week in practical chemistry; analyses of soils, ores, and metals are frequently made during the course, which extends from the sophomore year to the close.

TECHNICAL LABOR AND APPLICATION.

Students of the freshman and practical classes practice four hours a week upon all necessary farm work, under the charge of the professor of agriculture. Students in this class are divided into details for garden, field, yard, and grounds, and, under competent supervision, are instructed in whatever work the season may offer in these divisions. At the commencement of each week the respective details rotate, thus changing the work to each class.

A suitable compensation is paid to students on special volunteer detail, on Saturdays, during vacations, and during the hours from 4 to 6 p. m.

The laboratory work comprises work in agricultural chemistry; work in the microscopic department of botany and zoölogy; work in geological, mineralogical, and osteological cabinets; work in the veterinary dissecting and other rooms.

SPECIAL METHODS.

Especial attention is directed towards a cultivation of veterinary knowledge. A class of special agriculturists studying for farm superintendents, farmers, and teachers has been organized.

By an act of the last legislature the Commissioner of Agriculture was placed upon the board of trustees and tendered such portions of the farm, of 286 acres, as may in his judgment be necessary for the benefit of the government and State. Several plats are now devoted to a trial of the cereals.

COLLEGE BUILDING.

This is an imposing structure of brick, 120 feet long, 54 feet wide, 6 stories high, relieved by an east and south portico. The basement contains the dining room, kitchen,

*The annual expense for teaching staff is now $4,000, and is being reduced.

pantry, wash room, and bakery. On the first floor are the laboratory, museum, chapel, bath room, and department of languages. On the second floor, the parlor, visitor's room, president's room, registrar's office, commandant's office, room of officer of the day, English, agricultural, and mathematical rooms, society hall, and library. The chambers above are large, well ventilated, well heated, and lighted throughout with gas.

[Additional statements from latest reports received in this Office.]

THE SCHOOL OF AGRICULTURE.

It has been the aim of this institution, under the present direction, to make the school of agriculture the leading one in the college course. The acquisition to the faculty of Prof. A. Grabowskii has done much to make this possible. In the report of 1880 the professor states that an increased interest has been aroused, 41 students taking the course of agricultural studies.

The veterinary studies of this college have received a special evidence of approval in the offer of the New York Veterinary College of a free scholarship for an appointee of the Maryland institution, and the crediting also of the time spent at the college by all students entering therefrom.

The fair (for 1880) of the National Agricultural Society, held at Washington, was utilized by the Maryland college, the students visiting the fair and listening to explanatory lectures and statements.

THE FARM AND APPLIANCES.

The farm consists of 286 acres, with artificially drained meadows, also dry bottom and rolling uplands. There is a well selected herd of stock, animals for use and breeding.

The vegetable garden embraces ten acres, and several acres are laid down in fruit and flowers.

The national Department of Agriculture is utilizing the farm for experimental purposes to some extent.

THE COLLEGE COURSE,

The branches of study included in the college course are grouped under the following departments:

1. Civil engineering and astronomy.
2. English literature, mental science, and history.
3. Pure mathematics.
4. Physics and applied mathematics.
5. Agriculture, architecture, and natural history.
6. Chemistry.
7. Ancient and modern languages.

Physical geography is classed with civil engineering and astronomy; constitutional law with English literature, mental science, and history; calculus and mechanics with physics and bookkeeping; lectures on shades, shadows, and perspective and descriptive geometry with pure mathematics.

The studies of the school of agriculture are: *Freshman year*, general agriculture; *sophomore year*, geology, animal anatomy and physiology, botany, and zoölogy; *junior year*, horse and cattle raising, animal therapeutics, climatology, agronomy and manuring, general and special plant culture, diseases of animals and animal obstetrics; *senior year*, raising of swine, sheep, poultry, and bees, horticulture, vegetable gardening, agricultural implements and machines, agricultural technology and architecture, arboriculture and landscape gardening.

The practice comprises work on the farm and in the laboratories. For farm work, students are divided into garden, field, yard and grounds details, and instructed in whatever work the seasons may offer in these divisions. At the commencement of each week the "details" rotate, thus changing the work to each class. The special agricultural class is on practice detail daily from 2 to 4 p. m.; all freshmen, on Tuesdays and Thursdays from 2 to 4 p. m. For work done during the time from 4 to 6 p. m., during vacation and on Saturdays, a suitable compensation is paid to volunteer students.

The laboratory work comprises practice in the chemical laboratory (agricultural chemistry), in the microscopic department of botany and zoölogy, in the geological, mineralogical and osteological cabinets, and in the veterinary dissecting rooms.

MASSACHUSETTS.

MASSACHUSETTS AGRICULTURAL COLLEGE.

[Statement prepared from the latest reports in this office and from other sources.]

OBJECT.

Professor Levi Stockbridge,* president of the college, writes that "the leading object of this institution is education, as required by the act of Congress which gave us our endowment fund, but, technically, everything is made to contribute to science and practice in agriculture."

ENDOWMENT AND FUNDS.

The permanent college endowment consists of two-thirds of the fund created by the sale of the land scrip granted by the United States and held in the State treasury, and of certain donations from private benefactors, with the income therefrom derived. The full endowment fund, as derived from this sale and increased by the State, is as follows:

From sale of land scrip	$236,307	40
Profits on bond investment	10,067	40
Added by the State	141,535	35
	387,910	15

Of this total the State has expended $27,778.40 for an experimental farm, leaving the total permanent fund $360,067.67.

Of this amount, invested by the State so as to produce a little over 5 per cent. per annum, the agricultural college is endowed with two-thirds, or	$240,045	20
Value of farm purchased by State	27,778	40
Donated by the town of Amherst, for building purposes	75,000	00
Donation for constructing and stocking plant house	20,000	00
For herbarium	2,000	00
For scholarships, prizes and books (various)	7,751	00
By State appropriations from 1864 to 1879†	240,000	00
	612,574	60

The present income outside of legislative aid is derived from the land scrip fund and some additional sources (1881), and is as follows:

Income from State treasury	$12,958	00
Income from other funds	907	00
Income from tuition, &c	4,601	00
Income from all other sources	6,379	00
	24,845	00

Expenditures for 1881 were:

Salaries, &c	$11,137	00
Other expenses	11,444	00
	22,581	00

Value of realty, &c.

Buildings, farm, &c	$202,747	00
Other property	3,024	75
	205,771	75

THE FACULTY.

According to the catalogue of 1881 the college staff consisted of the president (professor of agriculture), professors of modern languages, chemistry, physics and civil engineering, botany and horticulture, military science, lecturers on veterinary science, geology, zoölogy, and entomology, and the superintendent of nurseries—10 in all.

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*Since succeeded by Hon. Paul A. Chadbourne, D. D., LL. D.
†Of this amount, $150,000 were designed for buildings and equipments.

DEGREES, STUDENTS, AND GRADUATES.

The college course continues four years. On graduation the degree of bachelor of science is received. An advanced course is open for college graduates and licentiates of scientific schools. The degrees are doctor of science or doctor of philosophy.

The number of students registered in the catalogue of 1881 was 113, 80 of whom were in the regular classes.

The tuition fees are $12 per term—$36 per annum. One free scholarship is awarded to each Congressional district in the State, the value of which is $144 per annum. The income from the bequest ($1,000) of Miss Mary Robinson, of Medfield, Mass., is bestowed by the faculty on such needy student as is deemed most worthy.

The number of graduates previous to 1882 was 181, to whom the degree of bachelor of science was given. A list of the graduates, with their occupations, is published from time to time. That given in the last report shows that some 37 graduates are engaged in farming; 28 as clerks, agents, salesmen and the like; 24 have entered the "learned professions" or are taking professional studies; 11 are in mercantile business; 10 are in manufacturing work; 10 are teachers, 5 of whom are in agricultural colleges; 9 are engineers or surveyors, 6 florists, 3 veterinary surgeons, 3 druggists, 3 chemists, and the remainder are occupied in a diversity of employments. Over 400 others have taken partial courses.

Professor Stockbridge writes: "By vote of the trustees of this institution females are invited here as students. In but one instance, however, has the opportunity been availed of." In the catalogue for 1879 a report of meteorological observations for 1878, by Miss Snell, is given.

COURSE OF STUDY.

Each collegiate year is divided into three terms. The studies for the first year are as follows: Chemistry, general and inorganic; human anatomy, physiology, and hygiene; algebra; English; agriculture; declamation; botany, general and systematic; geometry; elocution; freehand drawing; French; military drill; and manual labor for six hours each week, except in the second term.

For the second year: Systematic botany; geometry; French; English; agriculture; declamation; geology; lectures in history; trigonometry; drawing; zoölogy; surveying; leveling; military drill, and manual labor as before.

For the junior year: Mechanics; entomology; market gardening; horticulture; physics; practical chemistry; German; drawing; agricultural debate; astronomy; roads and railroads; stock and dairy farming; military drill four hours, and manual labor as before.

For the senior year: English literature; lectures in history; practical chemistry; bookkeeping; roads and railroads; military science; original declamation; thesis; mental science; agriculture; veterinary science; microscopy; botany; landscape gardening; rural law; lectures on English language; agricultural review; military drill.

APPLIANCES AND APPARATUS.

The students have the advantage of contiguity to Amherst College and its collections, library, and appliances, from which, though there be no direct connection, there cannot but be beneficial aids obtained to the students of the Agricultural College. The library property of the Agricultural College consists of over 2,000 volumes, mostly on technical subjects, embracing every department of agriculture and the natural sciences.

The Knowlton Herbarium contains more than 10,000 species of catalogued plants and botanical specimens.

The State cabinet of geology, ornithology, and entomology is complete in its illustration of the natural history of Massachusetts.

The chemical laboratory has accommodations for 70 students, and is in a high state of efficiency. Practical laboratory work is required of each student daily for an entire year.

The department of physics and civil engineering is fully equipped. Practical field work in surveying, laying out roads, &c., is required of every student sufficient to give him a knowledge of the most approved instruments and methods, to be pursued under a great variety of circumstances.

The military department affords facilities for valuable discipline, and is educating far more thoroughly and completely than any militia system can be expected to do a large number of young men, who go out capable of serving as officers or soldiers in case of emergency. This feature of the course of study and training is far more important than is generally supposed, and has from the first received the most careful attention by the college authorities, and has been eminently successful.

The horticultural department contains extensive plant and propagating houses, peach, pear, and apple orchards, vineyards, and nurseries, thus affording ample facilities for in-

struction and for the labor of students, who are paid by the hour for all work beyond the limits of what is called "class work," which is required of all students six hours a week as a part of the educational course.

The farm of nearly 400 acres must be regarded as an important adjunct of the college, as it affords facilities for observation and labor which could not be had without it. It has been somewhat cramped for means, and has been required to do a vast amount of work in the way of grading grounds, building roads and walks, and teaming of various kinds for the college, so that its accounts have not shown its actual working; but its capacities for usefulness in connection with other departments of the college are quite obvious.

The farm stock, though considerably diminished, owing to sales in order to meet indebtedness, still consists of 25 head, old and young, all but two of which are pure Ayrshires.

PRACTICAL RESULTS.

The farm is largely self-sustaining, and is in many ways profitable to the college. Its benefits experimentally considered are very great. The horticultural department is also nearly self-sustaining. The crops in 1880, with one or two exceptions, were good. The vineyard produced very well, and the crop yielded about $150. The nursery is in good condition, and contains a very large stock of peach and other fruit and ornamental trees, consisting of apple, pear, plum, and peach seedlings (root grafted or budded), quince stocks budded with pear, grape vines from cuttings, evergreens (mostly Japanese) from cuttings, a large stock of the umbrella pine, Japanese maple, &c.

The catalogue of 1880 says: "Though the education and training of young men must be regarded as the primary object, the contributions of the college to the science and practice of agriculture have been extensive and valuable, and they are universally recognized throughout the country as in the highest degree creditable to the institution and to the State; they have, indeed, in repeated instances been taken as the basis of important legislative action in other States. The following may be stated as a few of the subjects that have been investigated, most of them exhaustively and with valuable practical results:

"1. The growing of sugar beets, the manufacture of sugar from them, and trials of their value for cattle foods. This industry is soon to grow up in our midst and to absorb large amounts of capital.

"2. The sources of supply and the quantity and quality of our manurial agents. These careful scientific investigations have been the prime means of revolutionizing the manufacture and trade in fertilizers not only in this State but throughout the country.

"3. Laboratory and physical examinations of the South Carolina phosphates, and trials of their agricultural value in the raw state and after treatment with acids.

"4. On the use and effect of common salt on the grain and root crops.

"5. The chemical and physical condition of the salt marshes of the State, and the devising of methods by which they can be made available for agricultural purposes.

"6. Experiments with compound commercial fertilizers to test their comparative agricultural value and their value as compared with single elements.

"7. To determine what elements will make practically a complete manure on our average soils.

"8. Investigations of the quality and composition of commercial fertilizers offered for sale, and the protection of the community by legal control and inspection from frauds in them.

"9. Observations and study of the phenomena of plant life.

"10. The circulation of sap in plants, and their expansive power during growth.

"11. To determine the proportions of different elements of nutrition in feeding substances to be used to save needless expense and to produce the most certain results.

"12. Experiments on the continuous growth of crops on the same soil with chemical fertilizers alone.

"13. The influence of different kinds of fodder plants fed to milch cows on the quantity and quality of their milk and butter.

"14. Examinations and trials to test the comparative value of different methods of setting and treating milk in the butter dairy.

"15. Practical trials of new implements and a great variety of farm machinery.

"16. Investigations as to the effect of girdling fruit trees and plants to hasten the time of ripening and to improve the quality of the fruit.

"17. The effect of chemical salts on the carbo-hydrate contents of plants and the quality of fruits.

"18. The construction and repair of common roads.

"19. The growing of early amber cane and the manufacture of sugar from its juice.

"20. The influence of temperature on the vital functions of plants, and temperature of soils and air on the changes in forms of water in soils and plants and vapor in air.

"21. Investigations in relation to the evaporation and percolation of water from the soil.

"22. The tilling of soils of different characteristics as affecting the loss of water by evaporation.

"23. The determination of the elements of plant nutrition lost from the soil by leaching and of those it retains.

"24. Investigations in relation to the comparative temperature of the soil and air by day and by night.

"25. The establishment of true meridian lines to regulate the practice of surveying.

"26. The comparative study of the milk of different breeds of cows.

"27. Accurate investigations of the comparative nutritive and feeding value of northern, southern, and western varieties of Indian corn."

In further illustration of the work achieved in this direction, as well as in that of practical training, the following testimony is given:

Dr. James R. Nichols, editor of the Journal of Chemistry, chairman of the examining committee for 1878, says: "A prominent aim was to ascertain if the young men were really qualified to go upon a farm and conduct its operations in an intelligent and practical manner."

After a recapitulation of the range of knowledge required and information possessed by the students, Dr. Nichols says: "Upon these points and many others the young men were examined sufficiently in detail to bring out what they really knew; and it is gratifying to report that the answers showed marked proficiency in these departments of study."

In 1870, Professor Agassiz, acting as chairman of the examining committee, reported that the "theory of scientific agriculture is thoroughly taught, and the application of such knowledge is made on the farm, * * * and all students are compelled to work at the details of husbandry; so that manual labor becomes a valuable adjunct to mental application."

In 1873, Professor Agassiz declared, in reference to one of the papers referred to in the foregoing schedule: "Let me say to those who have not thought that the Agricultural College was doing anything worth its expense, that the production of this one paper has amply paid for every dollar which the State has thus far bestowed upon the institution."

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON.

[Statement from the latest catalogue and reports received at this office.]

OBJECTS.

This institution was organized under State charter in 1861 as an "institution devoted to the practical arts and sciences, having the triple organization of a society of arts, a museum or conservatory of arts, and a school of industrial science and art," and as a means of aiding "the advancement, development, and practical application of science in connection with arts, agriculture, manufactures, and commerce." The Congressional land grant for the State of Massachusetts and in aid of a college of agriculture and the mechanic arts was divided between the Agricultural College at Amherst and the Institute of Technology, the latter institution receiving one-third.

ENDOWMENTS AND FUNDS.

The endowment was obtained from the gifts of individuals and from the grant by the State of one-third of the land-grant fund. The latter amounted to $120,000 and the private donations were about $515,000. Of this latter sum $316,000 were invested in real estate, $54,000 in permanent property, and $145,000 are still regarded as productive funds, which, with the national endowment of $120,000 and a small additional sum, makes up $267,000 of permanent funds. The annual income and expenditure are each about $60,000, two-thirds of which is paid for salaries.

THE FACULTY.

The faculty of the institute has 40 members, divided as follows: President, professor emeritus of physics and geology; professors of mathematics (2), civil and topographical engineering, mechanical engineering, mining engineering, metallurgy and industrial chemistry, general chemistry, analytical and organic chemistry, physics, theoretical and

applied mechanics, architecture, geology and geography, zoölogy and palæontology, modern languages, and English history; assistant professors of architecture, architectural design, and modern languages; instructors in practical design, mechanical and free-hand drawing, physics, geology and mineralogy, military tactics, and civil engineering, with two others in the school of mechanic arts; and assistants in mechanical engineering, quantitative analysis (2), physics, general chemistry and qualitative analysis (3), chemistry and biology, drawing, and applied mechanics. There are also four instructors and assistants in the shops.

STUDENTS AND GRADUATES.

The number of students for 1880–'81 is given as follows:

Graduate students	15
Regular students:	
Fourth year	24
Third year	20
Second year	33
First year	87
Special students	138
In school of mechanic arts	39
In Lowell School of Practical Design	49
Deducting 15 (twice named) the total is	390

The number of graduates previous to 1880 was 244, whose occupations are approximately stated as follows: Civil engineers, 45; teachers, instructors, &c., 26; chemists, 22; draughtsmen, 16; manufacturers, 13; in business, 13; superintendents of mills, &c., 11; mining engineers, 10; mechanical engineers, 8; deceased, 14; miscellaneous employments, 54; not reported, 12. There were 8 graduates in 1880 and 28 in 1881.

Tuition is charged as follows: The institute proper, $200; school of mechanic arts, $150; average expense per scholar, $254.22. There are ten free scholarships: five in the advanced or graduate course, three undergraduate, and two in the school of mechanic arts. On the 1st of February, 1881, there were 35 young women in attendance, of whom 14 were in the scientific department and 21 in the Lowell school of practical design.

THE COURSE OF INSTRUCTION.

Five of the regular courses open to students are purely professional in character and are designed to train for active careers therein. These courses are: 1, civil and topographical engineering; 2, mechanical engineering; 3, mining engineering, or mining and geology; 4, building and architecture; 5, chemistry.

THE STUDIES OF THE PROFESSIONAL COURSES.

The studies of the first year are common to all the courses, and embrace the following subjects: Algebra, geometry, plane and spherical trigonometry, chemistry, qualitative analysis, laboratory work, rhetoric, English composition, English history and literature, French, drawing, military drill.

COURSE IN CIVIL ENGINEERING.

The studies of this course are:

Second year.—Surveying, leveling, field practice, plotting from notes, topography, analytic and descriptive geometry, differential calculus, physics, descriptive astronomy, physical geography, English history and literature, German.

Third year.—Roads and railroads, engineering drawing, integral calculus, statics, general hydraulics, rivers and harbors, locks, dams, and canals, field practice, strength of materials, cinematics and dynamics, physics, lectures and laboratory work, constitutional history, political economy, German.

Fourth year.—Framed structures, water supply, sewerage of cities and towns, drainage and irrigation, details of construction, study of actual works, specifications and contracts, theory of elasticity, dynamics, strength of materials, building materials, metallurgy, history of engineering, thesis work.

COURSE IN MECHANICAL ENGINEERING.

Second year.—Setting of machines, transmission and production of power, cinematics of machines, machine drawing, analytic and descriptive geometry, differential calculus,

physics, descriptive astronomy, physical geography, English history and literature, German, pattern and foundry work (shopwork), carpentry.

Third year.—Combustion of fuel, steam generators and steam engines, machine drawing, machine design, elements of thermodynamics, steam engineering laboratory, integral calculus, general statics, strength of materials, blacksmithing (shopwork), physics, lectures and laboratory work, constitutional history, political economy, German, cinematics and dynamics, chipping and filing (shopwork).

Fourth year.—Machine design, measurement and regulation of power, machine drawing, thermodynamics of steam and other heat engines, pumping engines, hydraulic motors, machines and regulators, abstracts from memoirs, steam engineering laboratory, strength of materials, hydraulics, metallurgy, theory of elasticity, dynamics, building materials, blacksmithing (shopwork), engine lathe work (shopwork), thesis work.

COURSE A IN MINING (ENGINEERING).

Second year.—Blowpipe analysis, crystallography, and determinative mineralogy, qualitative and quantitative chemical analysis, lectures and laboratory work, use of survey instruments, surveying, field practice, drawing, analytic geometry, differential calculus, physics, physical geography, English history and literature, German.

Third year.—Quantitative chemical analysis, mining engineering, sinking, timbering, hoisting, pumping, ventilating, etc., integral calculus, general statics, strength of materials, cinematics and dynamics, physics, lectures and laboratory work, assaying, structural, chemical and historical geology, constitutional history, political economy, German.

Fourth year.—Quantitative chemical analysis, mining laboratory (work upon gold, silver, copper, and lead ores in quantity), metallurgy lectures, ore dressing lectures, drawing, strength of materials, building materials, dynamics, welding and tempering, memoirs, thesis.

COURSE B IN MINING (GEOLOGY AND MINING).

Second year.—Blowpipe analysis, crystallography, and determinative mineralogy, quantitative chemical analysis, use of surveying instruments, surveying, field practice, drawing, physical geography, zoölogy, palæontology, botany, physics, German.

Third year.—Mining engineering, sinking, timbering, hoisting, pumping, ventilation, etc., quantitative chemical analysis, assaying, industrial chemistry, zoölogy, palæontology, physics (lectures and laboratory work), structural, chemical and historical geology, constitutional history, political economy, German.

Fourth year.—Quantitative chemical analysis, mining laboratory (work upon gold, silver, copper, and lead ores in quantity), metallurgy lectures, ore dressing, drawing, applied physics, building materials, welding and tempering (shopwork), memoirs, thesis work.

COURSE IN ARCHITECTURE.

Second year.—Greek, Roman, and medieval architectural history, the orders and their applications, drawing, tracing and sketching, analytic geometry, differential calculus, physics, descriptive geometry, descriptive astronomy, botany, physical geography, English history and literature, German.

Third year.—Theory of decoration; color, form and proportions; conventionalization, symbolism, modern architectural history, the decorative arts, stained glass, fresco painting, tiles, terra cotta, etc., original designs, sketching, specifications, integral calculus, general statics, strength of materials, cinematics and dynamics, bridges and roofs (descriptive), stereotomy, structural geology, physics, lectures and laboratory work, constitutional history, political economy, German.

Fourth year.—The history of ornament, the theory of architecture, style and composition, drawing, original design, sketching, specifications, strength of materials, building materials, stability of structures, flow of gases, carpentry (shopwork), thesis work.

COURSE A IN CHEMISTRY.

Second year.—Qualitative analysis, quantitative analysis (lectures and laboratory work), blowpipe analysis, crystallography, and determinative mineralogy, chemical philosophy, analytic geometry, differential calculus, physics, English history and literature, German.

Third year.—Quantitative a analysis, special methods and laboratory work, industrial chemistry, lectures, work with the microscope, assaying, physics (lectures and laboratory work), physical geography, drawing, constitutional history, political economy, German.

Fourth year.—Organic chemistry, lectures and laboratory work, metallurgy, lectures, abstracts of memoirs, applied physics, optional studies.

Studies for the second term, including thesis work, will be specially assigned to each student.

COURSES B AND C IN CHEMISTRY.

Second year.—Qualitative analysis, quantitative analysis (lectures and laboratory work), blowpipe analysis, crystallography, and determinative mineralogy, chemical philosophy, botany, physical geography, physics, descriptive astronomy, English history and literature, German.

Third year.—Quantitative analysis (laboratory work and special methods), industrial chemistry lectures, biology, assaying, physics, lectures and laboratory work, structural, chemical and historical geology, drawing, constitutional history, political economy, German.

Fourth year.—Course B: Organic chemistry (lectures), chemistry (laboratory work), metallurgy (laboratory work), abstracts of memoirs, applied physics, optional studies. Course C: Organic chemistry (lectures), chemistry (laboratory work), industrial chemistry (laboratory work), metallurgy (lectures), abstracts of memoirs, applied physics, optional studies.

Studies for the second term, including thesis work, will be specially assigned to each student.

THE STUDIES OF THE NON-PROFESSIONAL COURSES.

The course in metallurgy is similar to that in chemistry, but has more particular reference to the production and working of the metals. The course in natural history affords an appropriate general training for those whose ulterior object is the special pursuit of geology, mineralogy, botany, zoölogy, pharmacy, or rural economy. It is specially suitable for those who intend subsequently to enter upon the medical profession.

The course in physics is based on the mathematical and physical sciences, and offers a suitable preparation for persons desirous of fitting themselves to teach physical science, as well as for those desiring to enter upon the pursuit of the various practical applications of physics, as making physical tests of materials.

In view of the rapidly increasing development of the various branches of electrical engineering, and the consequent demand for persons conversant with the theory and applications of electricity, a course of instruction has just been established bearing more directly upon this subject than any of those which have hitherto been offered. It constitutes an alternative course in physics differing from the one previously existing chiefly in the continued study of electricity, instead of a pursuit of other branches of physics, and in the introduction of a considerable amount of practice in the laboratory of mechanical engineering and the workshops, in place of chemical analysis. A knowledge of the theory of electricity will be given sufficiently extensive to prepare for ordinary electrical work and advanced study. Instruction in the various methods of electrical testing, and special instruction regarding land and submarine telegraphy, the telephone, electric lighting, the electrical transmission of power, and acoustics as involved in telephony will be given.

Certain general courses have been established for such as may not intend to adopt a distinctly scientific profession and yet desire to obtain an education through studies of a predominantly scientific character. Each of these courses contains a solid body of scientific study and of scientific field or laboratory work. In the first, physics, with the requisite mathematics, predominates among the scientific studies; in the second, chemistry, with the closely related sciences of botany and physiology; in the third, geology, with botany and zoölogy, forming a thorough course in biology, with field work and laboratory practice, especially with the microscope.

All the regular courses of the institute, whether professional or general, extend through four years, and for proficiency in any one of them the degree of S. B., bachelor of science, is conferred.

Advanced courses of study may be pursued, and the granting of the degree of doctor of science has been authorized by a vote of the corporation.

INDUSTRIAL INSTRUCTION.

INSTRUCTION OF WOMEN.

The Lowell School of Practical Design, described further on, though open free to both sexes, seems to be adapted more directly to the female students, so that a majority in attendance are young women. They have also become members of various other classes, and largely availed themselves of the opportunities for technical education. Special laboratories have been provided for their instruction in chemical analysis, industrial chemistry, min-

eralogy, and biology. This instruction is arranged for those who by reason of other engagements can spend only a few hours a week in these exercises as well as for such as can devote their whole time to the work. Other instruction is given so far as suitable arrangements can be made.

SCHOOL OF MECHANIC ARTS.

The School of Mechanic Arts is designed for industrial education as distinguished from that given professional engineers and chemists. It embraces manual and technical instruction in the shop as well as an opportunity to continue elementary literary and scientific studies. It is designed for students who have completed the ordinary grammar school course. Students continue their elementary literary and scientific studies while receiving instruction in the use of tools and machines. The plan of shop work adopted is the same as that of the Imperial Technical School at Moscow, Russia. The studies are, in addition to shop work:

For the first year, algebra to equations of the second degree, plane geometry, mechanical drawing, and English composition.

For the second year, algebra, physics, mechanical drawing, and English composition.

The shop courses of the school are as follows: for the first year, carpentry and joinery, wood-turning, pattern-making, foundery work; and for the second year iron-forging, vise work, and machine tool work.

Two years cover the full course. It begins with simple lessons in carpentry and gradually goes on to more difficult exercises requiring accuracy and judgment. Beginning with the chalk-line and a piece of rough board, the pupil proceeds with sawing, planing, squaring, jointing, mitering, nailing, boring, dove-tailing, mortising, and framing, receiving intermediate lessons in the design, structure, and care of tools. * * * Wood-turning and pattern-making come next to round out his instruction in the working of wood. The use of the pattern is illustrated by a series of lessons in moulding, core-making, and casting. In the second year of the course the pupils enter the blacksmith's shop, where they are first taught how to build and manage the fire; next how to heat and how to strike the iron; then, consequently, how to bend, draw out, upset, shape, weld, punch, bore, and rivet; how to heat, weld, and temper steel, how to case-harden iron. The articles made for illustration are required to be of the precise forms and dimensions given in drawings, and made with the fewest possible heatings. The aim is to teach the pupil to accomplish what is wanted with the fewest blows and the least waste of material. In forty-five lessons of three hours each the pupil has practice in operations of every kind that a blacksmith is called upon to perform, and he is enabled to do work that would not be discreditable to the practical journeyman. The material used is of inconsiderable cost, and the articles made are of interest to the worker to call to mind just how the work was done in each case. If he used due diligence he is justly proud of his work and is allowed to keep it. After a short course in chipping and filing cast-iron, wrought-iron, and steel, the pupil finishes his course with a series of exercises in lathe and plane work. It is desirable to extend the course and include some other branches, such as soldering, brazing, plumbing, painting, varnishing, &c. To all these arts, and many more, the method of instruction may be adapted, keeping constantly in view the main purposes, elementary instruction, moderate expense for tools, and very little expense in the cost of material consumed.

FREE TECHNICAL INSTRUCTION.

The trustee of the Lowell Institute has established, under the supervision of the Institute of Technology, courses of instruction, generally in the evening, open to students of either sex free of charge. These courses are more or less varied from year to year by the omission or interchange of particular subjects, but include in their entire scope instruction in mathematics, physics, drawing, chemistry, geology, natural history, physiology, English, French, German, history, navigation and nautical astronomy, architecture, and engineering. They have also made provision for a course of free instruction in practical design for manufactures, open to a limited number of pupils of either sex. Students are received at the beginning of the school year in September, to whom is taught the art of making patterns for prints, delaines, silks, paper-hangings, carpets, oilcloths, &c. The course embraces original design or composition of patterns, secondary design or variation of patterns, the making of working drawings, and technical manipulations. This school is doing excellent work, and is especially availed of by young women. It is under the personal direction of Mr. Charles Kastner, formerly of the Atelier Le Bert, Paris, and for fourteen years designer at the Pacific Mills, Lawrence, Mass. The school is provided with pattern looms.

The Massachusetts Charitable Mechanics' Association has founded two free scholarships in the School of Mechanic Arts, for sons of past or present members of the association. The Public Library of Boston is placed at the full use of professors and students.

APPLIANCES AND APPARATUS.

The institute is amply provided for its work. Laboratories, well fitted and fully equipped, are devoted to chemical studies, mineralogy, metallurgy, and to industrial chemistry. In the new buildings there is a properly arranged laboratory for the women students, with balance and reception rooms. The industrial chemical laboratory and the microscopic and spectroscopic laboratory are in the same building; also the organic chemical laboratory.

In physics the institute is provided with ample apparatus and the Rogers Laboratory for advanced students. There are also laboratories of steam engineering, of mining and metallurgy, of biology, and the museum of architecture; also the observatory. The last named is used to great advantage in connection with instruction in geodesy and is a means of studying practical astronomy. The laboratory of steam engineering provides practice in testing, adjusting, and managing steam machinery and apparatus. The appliances in connection with mining and metallurgy include a five-stamp battery complete, Blake crusher, automatic machine jigs, a spitzkasten, also engine pulverizer, a Root and a Sturtevant blower, with blast, reverberatory, wasting, cupellation, and fusion furnaces, and all other necessary machinery for reducing and smelting ores. There is a large collection of models. The architectural museum contains several thousand models, casts, photographs, prints, and drawings. The museum of fine arts, whose collection is close by, is open to students. The biological laboratory has a full outfit of microscopes and accessory apparatus.

The shops for handwork, recently fitted up, are quite large and well arranged. They include a vise-shop, forge-shop, machine, tool, or lathe shop, foundery, rooms for pattern making, weaving, and other industrial instruction. The vise-shop contains four heavy benches, with 32 vises attached. This gives a capacity for teaching 128 students the course every ten weeks, or 640 students in a year of 50 weeks. The forge-shop has eight forges. The foundry has 16 moulding benches, an oven for core baking, and a blast furnace of one-half ton capacity. The pattern weaving room is provided with five looms, one of them a twenty-harness and four-shuttle loom, and another an improved Jacquard pattern loom.

SCHOOL OF MECHANIC ARTS.

The attention which has been directed to manual training schools makes it desirable to present a further and more extended account of what is being done in this direction in the Massachusetts Institute of Technology. The following extracts, taken from the Forty-fifth Annual Report of the Massachusetts Board of Education, were written by Prof. John D. Runkle.

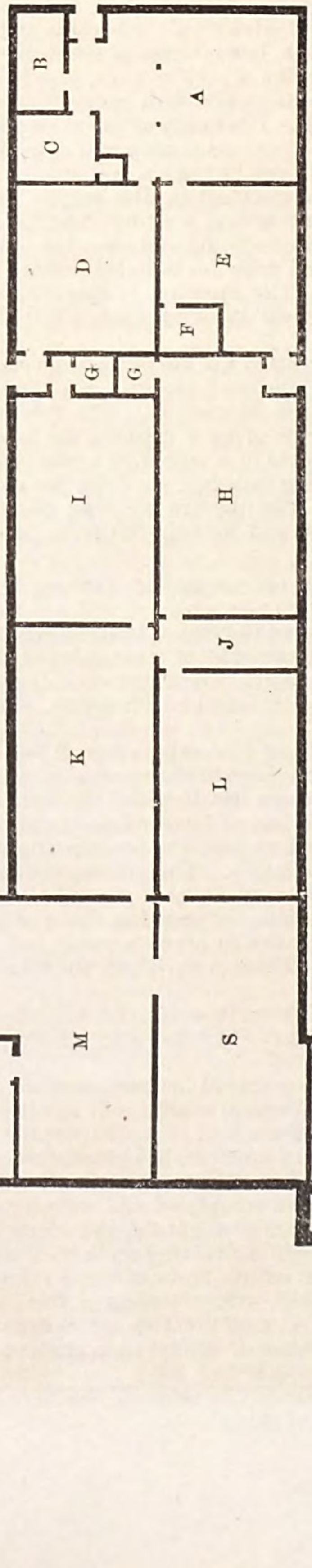
This school was founded by a vote of the corporation of the institute dated August 17, 1876. Since October 1, 1878, it has been in charge of a committee of the faculty, Prof. John M. Ordway, chairman, upon whom has devolved the main direction of the school. While adhering to the spirit and method of instruction, the aim has been to make the work in all departments as practical as possible, by selecting useful forms, if equally good, to teach the particular manipulation. The accompanying pages of cuts showing series of samples used in the shops are given as a general illustration, and not as the only, or even necessarily the best, series, for teaching the manipulations in each case. Every qualified teacher will naturally design his own course, and will also modify it from time to time as experience suggests. There is obviously the same freedom here as in the teaching of other subjects.

The mechanic art courses are as follows: In *wood:* (1) carpentry and joinery; (2) wood-turning; (3) pattern-making. In *iron:* (1) vise-work; (2) forging; (3) foundry-work; (4) machine-tool work.

While these shops are used for the practical instruction of our students in mechanical engineering, and for such other professional students of the institute as desire it, they are most largely used by students in the school of mechanic arts. This school, in which special prominence is given to *manual* education, has been established for those who wish to enter upon industrial pursuits rather than to become scientific engineers. It is designed to afford such students as have completed the ordinary grammar-school course an opportunity to continue the elementary, scientific, and literary studies, together with mechanical and free-hand drawing, while receiving theoretical and practical instruction in these various arts, including the nature and economic value of the materials with which they deal. Nine hours per week—three lessons of three hours each—of the students' time are devoted to shop work, and the balance to drawing and other studies, only one shop course, except in the case of special shop students, being carried on at a time.

It may be well now briefly to indicate the steps necessary to be taken in fitting up a shop and in working out the course of study.

FIG. 1.



NEW TEMPORARY BUILDING FOR SHOP-WORK AND CHEMISTRY,

A. Woman's Chem. Lab., 27′ 6″ by 24′ 6″.
B. Balance Room, 14′ 6″ by 7′.
C. Reception Room, 11′ by 9′ 6″.
D. Industrial Chem. Lab., 24′ by 20′.
E. Microscopical Laboratory, 24′ by 20′.
F. Dark Room, 9′ 6″ by 6′.
G. G. Tool and Stock Rooms, 6′ by 6′.
H. Machine-Tool Shop, 37′ by 20′.
I. Pattern Weaving, 32′ 6″ by 20′.
J. Engine Room, 20′ by 7′ 9″.
K. Forging Shop, 39′ by 20′.
L. Chipping and Filing Shop, 23′ 6″ by 20′.
M. Foundry, 41′ by 20′.
N. Wash Room, 13′ 6″ by 9′ 6″.
O. Organic Chem. Lab., 19′ by 14′.
P. Special Work Room, 13′ by 9′ 6″.
Q. Store, 9′ 6″ by 6′.
R. Ice-Chamber, 8′ by 5′.
S. Carpentry and Joinery, Wood-turning and Pattern-making, 50′ by 20′.

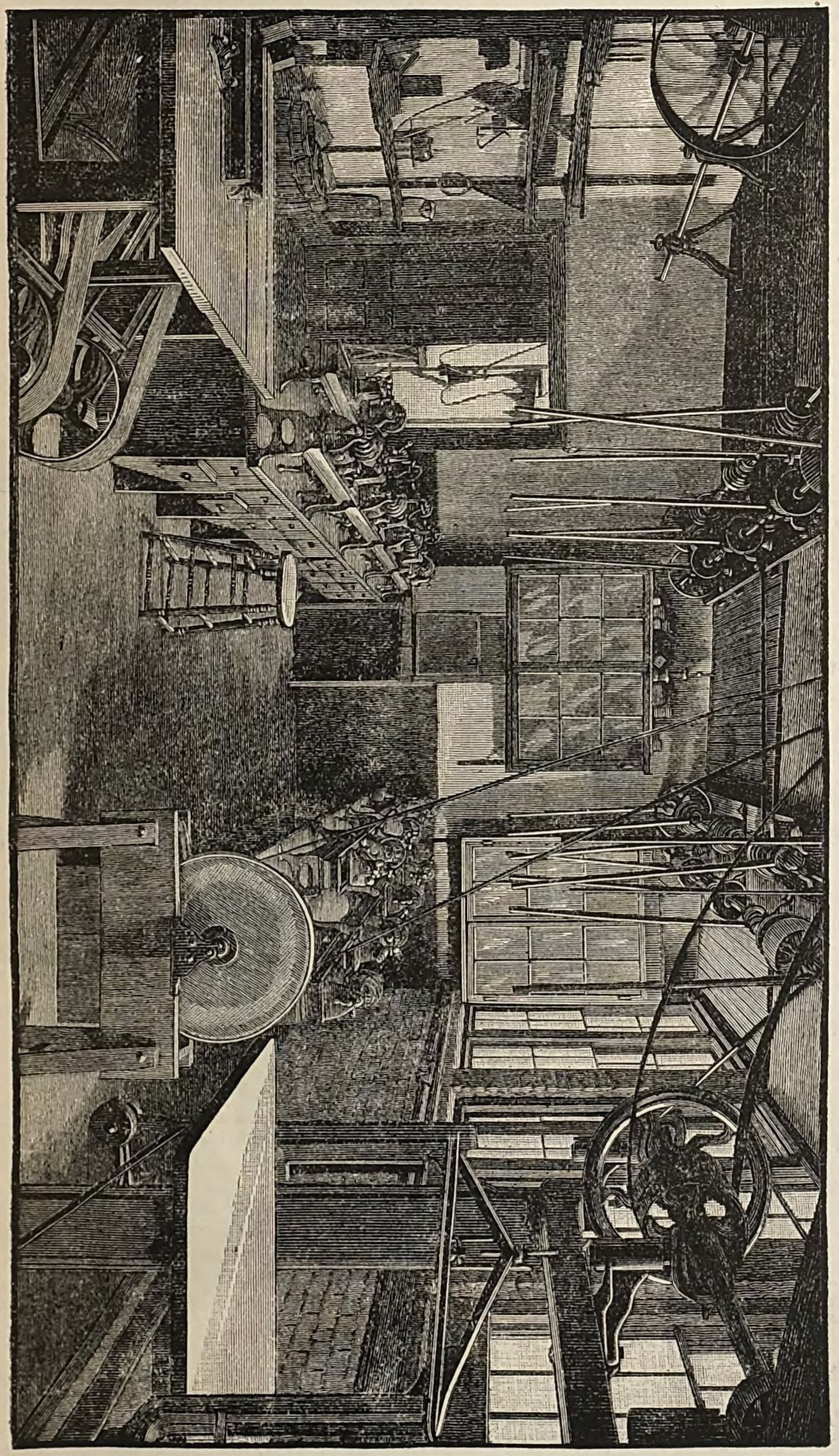


FIG. 2.

CARPENTRY, JOINERY, WOOD-TURNING AND PATTERN SHOP.

The shop.—1. Settle upon the tools and appliances to be used during the course. 2. Decide how many students can be taught in a section. 3. Design the fitting up of the shop, giving each student the proper space and facilities, and so arrange that each stu-

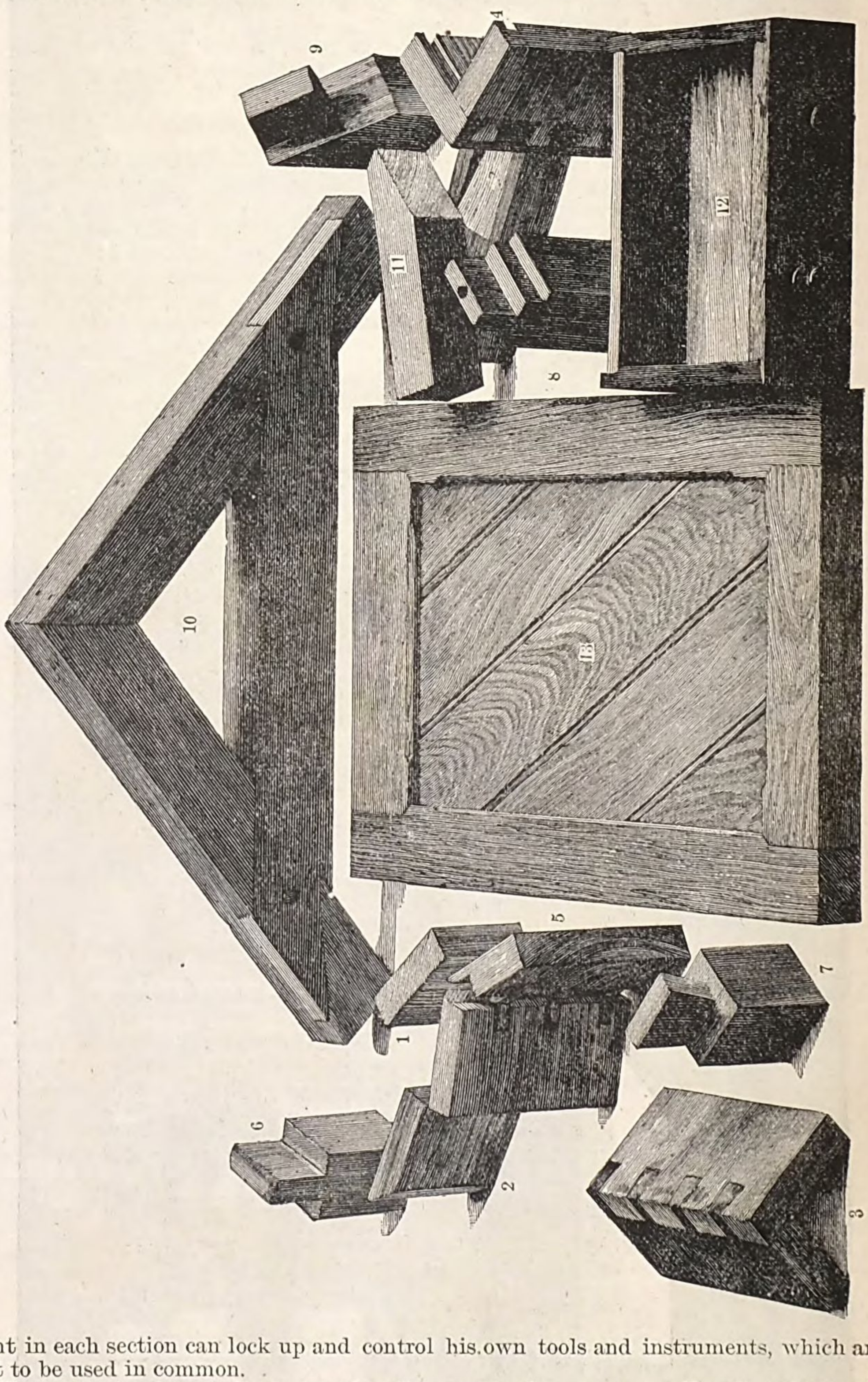


FIG. 3.—COURSE IN CARPENTRY AND JOINERY.

dent in each section can lock up and control his own tools and instruments, which are not to be used in common.

The course of study.—1. Design a series of progressive lessons, especially adapted to teach the use of the set of tools and appliances pertaining to each course. 2. Let the master work each lesson or sample, that he may settle clearly in his own mind the best method of solution, with a statement of the reasons therefor. 3. A system of inspection upon which the quality of the work can be based and each student given his proper percentage, and

which shall also be the means of educating the judgment of the student, that it may keep pace with his skill of hand to execute.

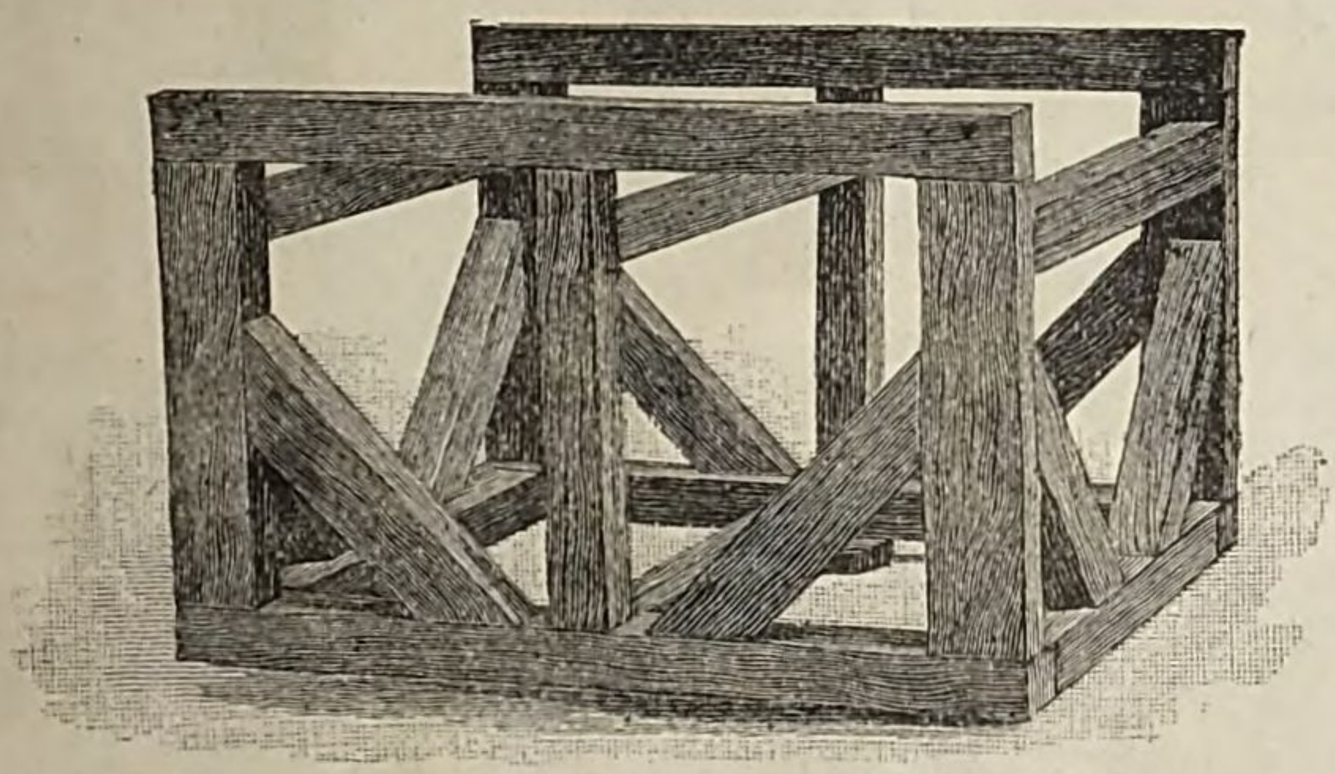
We find, then, that in this practical part of the problem there are three distinct educational steps. First, the best method of solution; second, skill of hand to execute the work; third, the capacity to judge of the quality of the work.

The theoretical studies are arithmetic, algebra, geometry, English, physics, and drawing. The shops are arranged for teaching sixteen in a section, except that for forging, which contains only eight forges, on account of the smallness of the room. The deficiency has been remedied as far as possible by enlarging the foundry and using portable forges.

All our shops are entirely to small for the work we are endeavoring to do in them, and the present temporary building must soon be replaced by a larger and better adapted one if the purposes of the school are ever fully realized.

The carpentry, joinery, wood turning, and pattern shop.—This shop is 50 by 20 feet, one end containing the carpentry and joinery benches and the other the wood turning lathes shown in the cut. The lathes are placed four on each side of two benches, and under each lathe are four drawers to hold the tools of the four sections. The carpentry and joinery benches at the other end of the room are similarly arranged. In the middle of the room the cut shows the saws for cutting up the lumber to the dimensions needed in the courses of instruction.

FIG. 4.



The first instruction in carpentry and joinery is the use of the saw and plane in working wood to given dimensions, and then a series of elements follow in order (Fig.3): No. 1, a square joint; 2, a mitre joint; 3, a dovetail joint; 4, a blind dovetail; 5, a mitre dovetail; 6, a common tenon; 7, a key tenon; 8, a tusk tenon; 9, a brace tenon; 10, a *pair* of rafters with collar-beam; 11, a truss tenon; 12, a drawer; 13, a panel. In addition to the above, each student makes a small frame, to apply several of the elements of the previous lessons. A sample is given in Fig. 4.

The instruction in turning (Fig. 5) and circular section pattern making is given in the following series of models: Nos. 1, 2, and 3 represent a series of manipulations in simple turning; 4, 5, and 12, pulleys; 9, a globe valve; 6, 7, 8, 10, 11, 13, and 14, patterns for various forms of pipes. Corresponding core patterns form part of the course. Bench patterns and bench and lathe combined are not included for want of space.

The instruction in this shop is given by Mr. George Smith, assisted by Mr. Z. Nason.

The foundery.—The cut representing the foundery shows a part of the sixteen moulding benches, combined with troughs for holding the sand, with the cupola furnace at the other end of the room. Over the furnace is seen the Sturtevant fan, which exhausts the heat and dust from the blacksmith's shop beyond. The furnace connects with a flue, which passes out of the shop, thence underground, into a chimney in the rear end of the main institute building. The blast for the furnace is taken from the pipe shown over the door, in the rear right hand corner of the room. An average charge of the furnace is about 500 pounds.

Foundery course.—Nos. 1, 2, 3, 4, and 5 are pieces used in the course of filing and chipping; 6 and 7, curved castings; 8, a sheave; 9, a pulley; 10, a pulley; 11, an eccentric; 12, a clutch; 13, 14, 15, 16, 17, 18, and 21, parts of a loom; 19 and 20, cog wheels; 22, a rack; 23, a shield.

The forging shop.—This shop is fitted with eight forges. The Sturtevant pressure blower, which furnishes the blast for the forges, is placed in the engine room. The hoods over the forges are connected with a 16-inch pipe, which runs longitudinally near the ceiling of the shop and enters a No. 4 Sturtevant exhaust blower in the foundery. This exhaust blower removes all smoke and dust and much of the heat. This shop was planned and fitted by Mr. B. F. Sturtevant, of Boston, at his own expense. The school is also indebted to him for other valuable assistance.

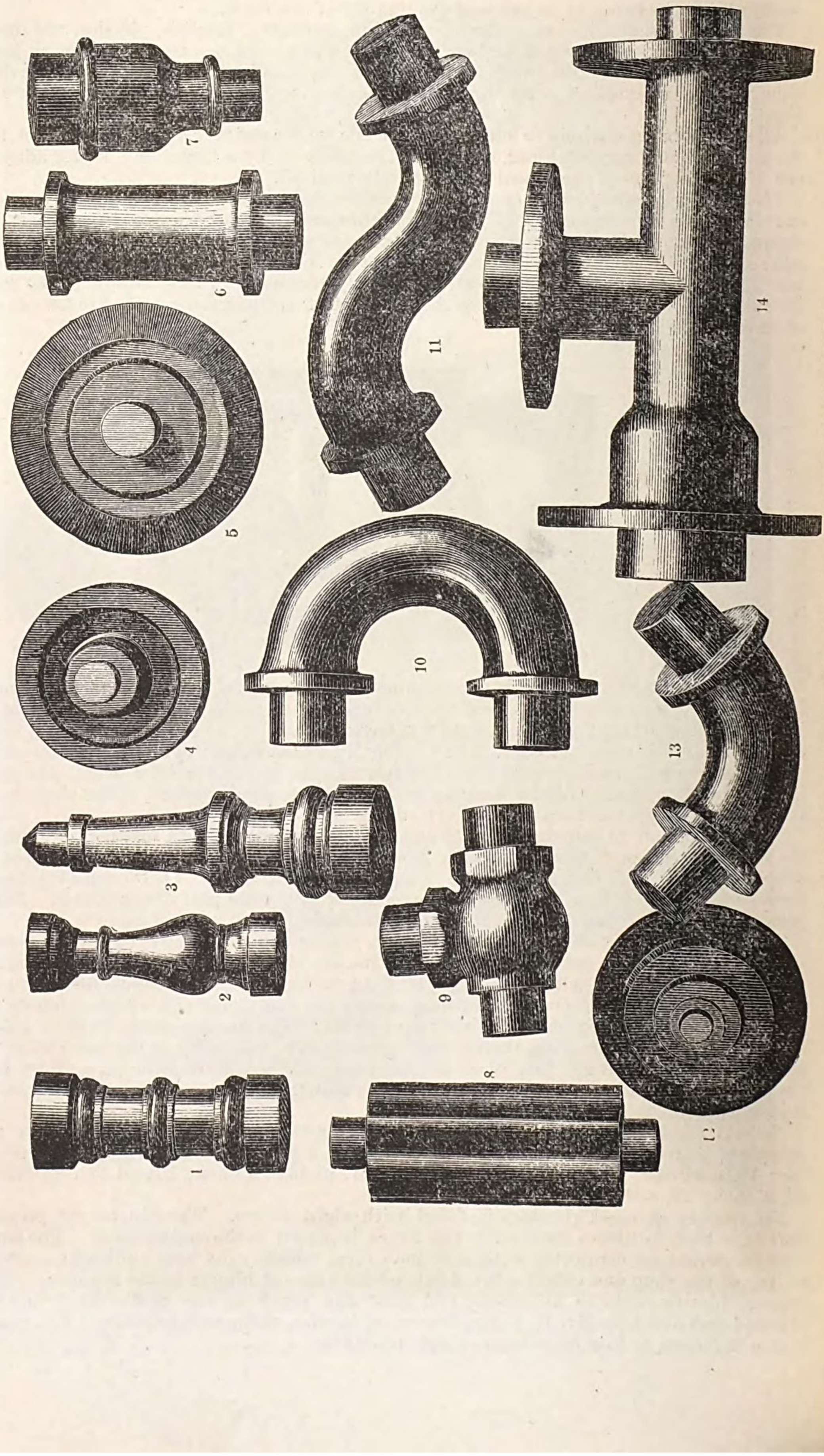
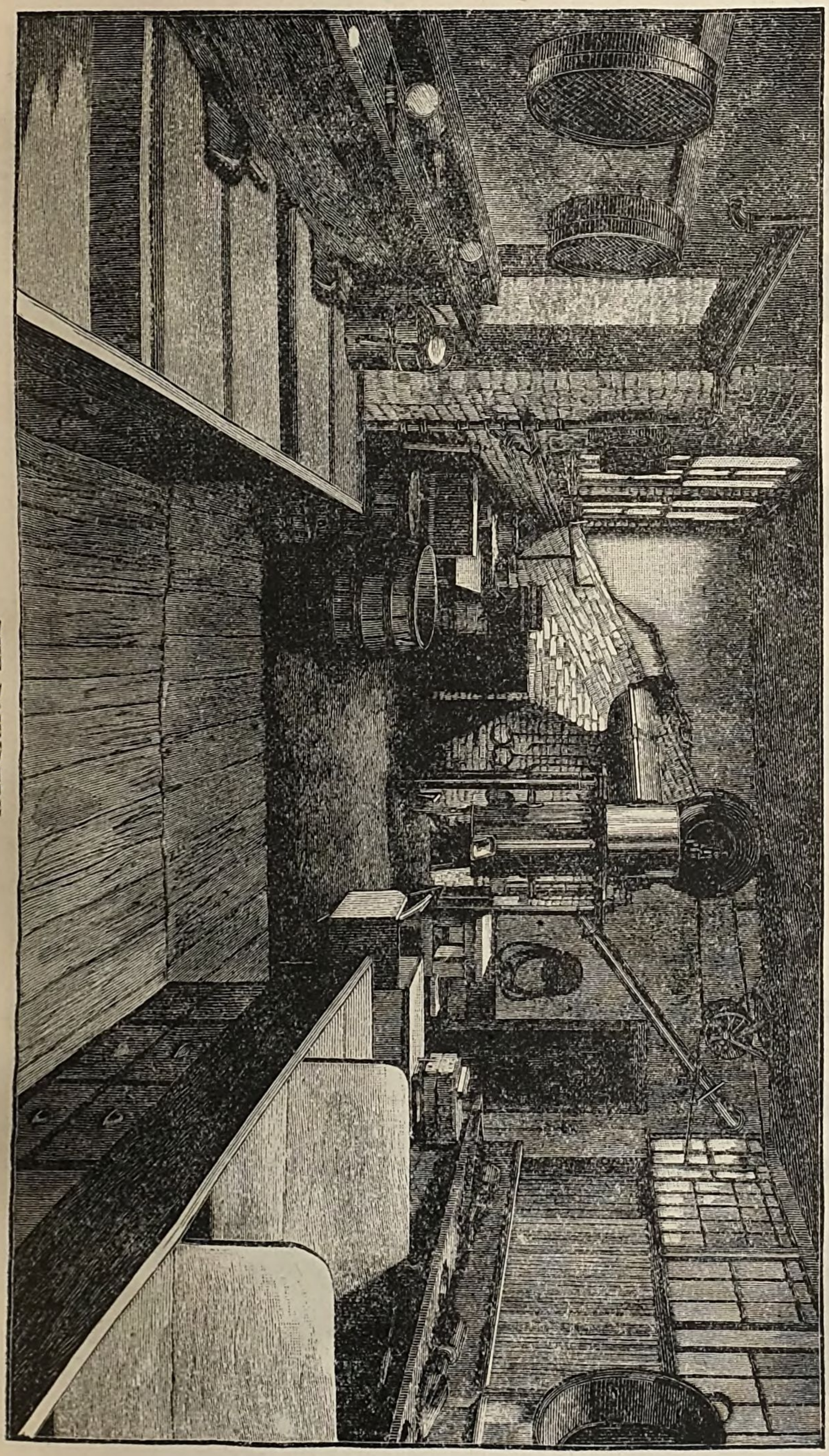


FIG. 5. WOOD TURNING AND PATTERN MAKING.



THE FOUNDERY.

FIG. 6.

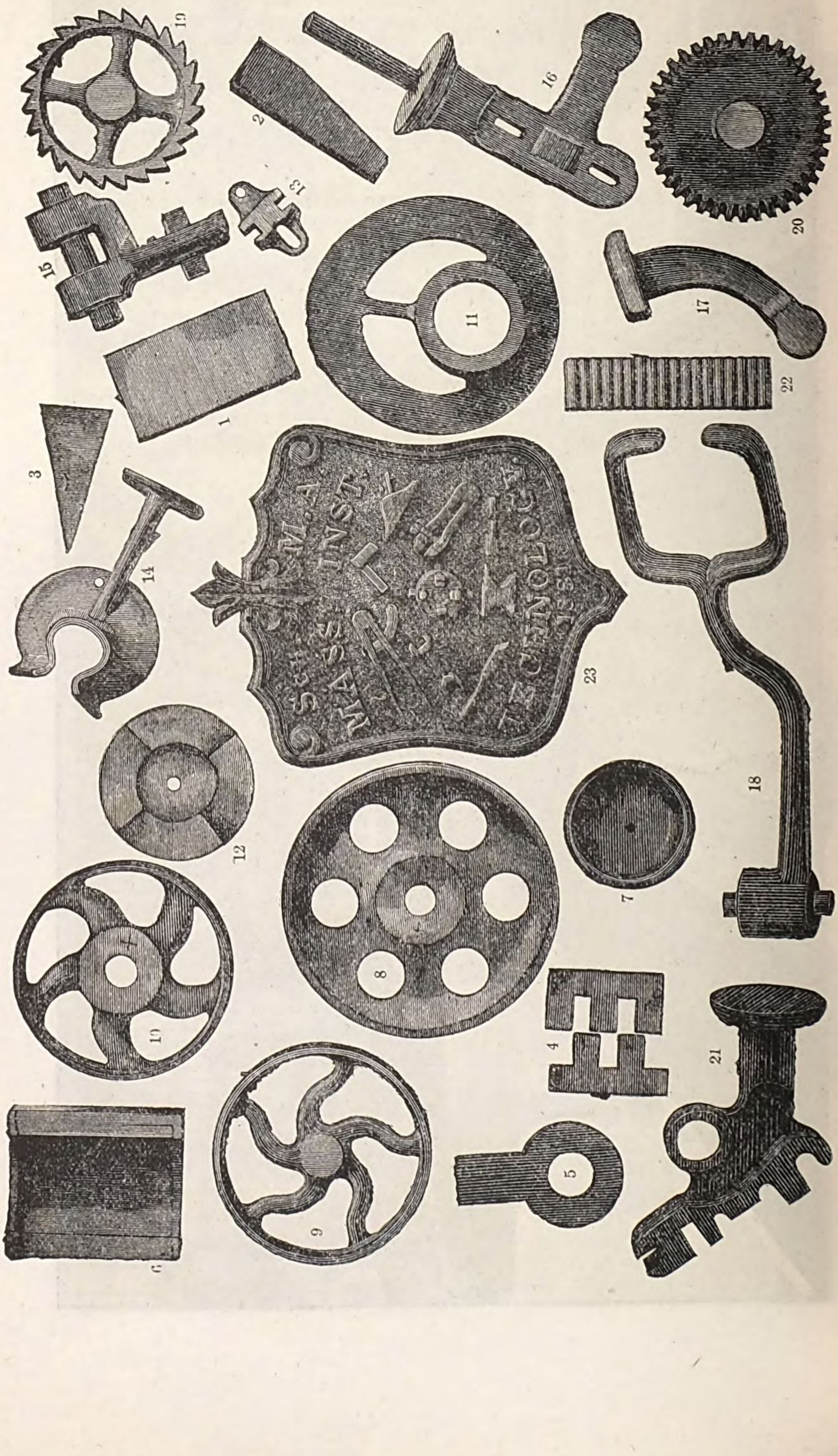


FIG. 7. COURSE IN FOUNDERY WORK.

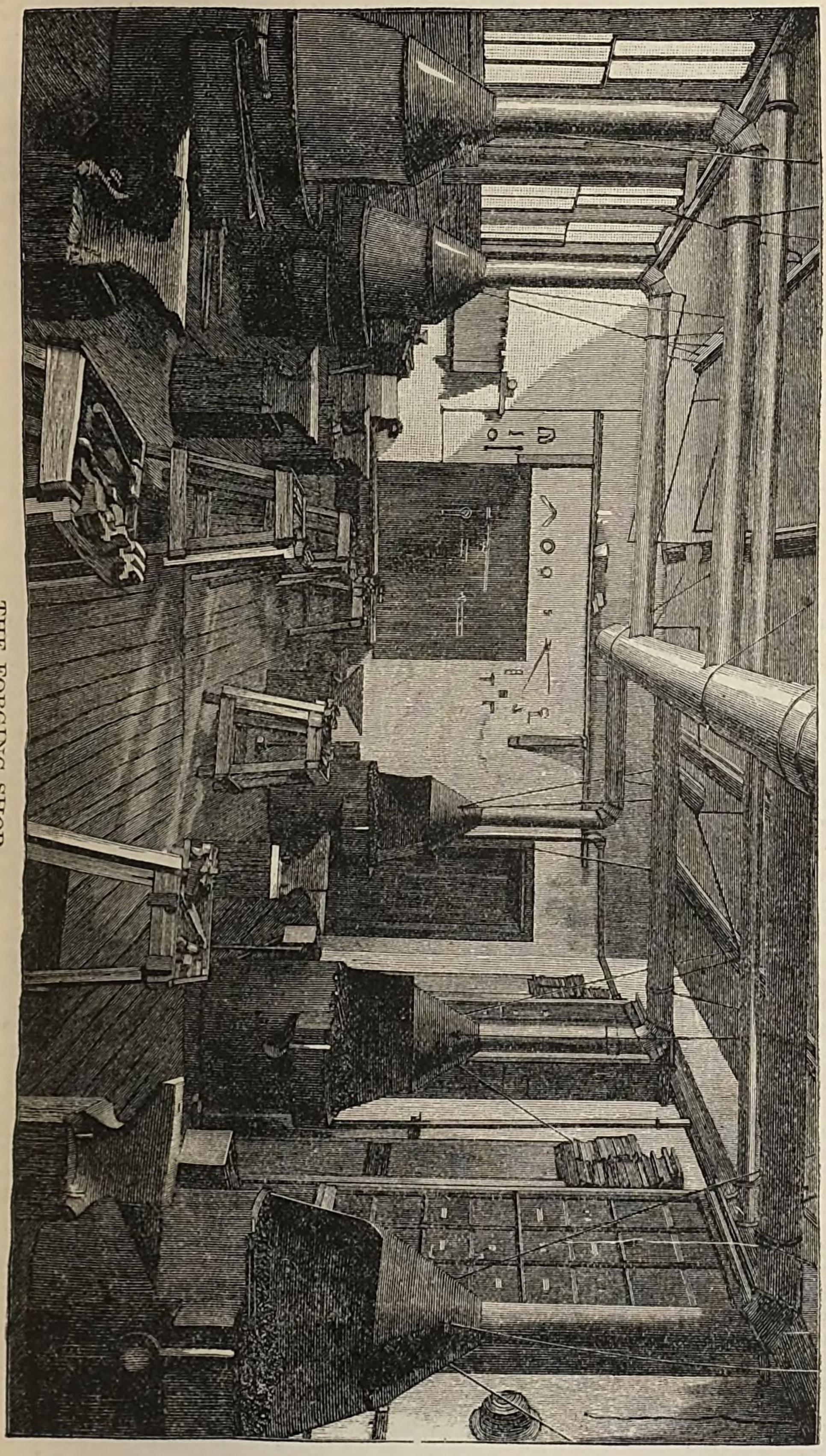


FIG. 8.—THE FORGING SHOP.

The machine tool shop.—This shop contains sixteen engine lathes of $4\frac{1}{2}^1$ bed, four speed lathes, and a Brainard milling machine. The engine lathes were made for the school by the Putnam Machine Company, of Fitchburg, Mass., from new designs, and furnished at a greatly reduced cost, and have proved in all respects first class tools. Under each lathe is a chest of drawers to hold the tools belonging to the student using it. A bench under the window holds the requisite number of vises. The shop needs a variety of additional tools, which are not furnished for want of room.

The chipping, filing, and fitting shop.—This shop contains benches with sixteen vises and other needful appliances, with a planer, grindstone, &c., for which there is no room in the machine tool shop. The instruction in forging, vise work, and machine tool work is in charge of Mr. Thomas Foley, a thorough and skillful mechanic, who has served his seven years' apprenticeship, and has had, besides, a long and varied experience in his profession. He has a clear comprehension of the problem of mechanic art education, and has during the past five years shown equal capacity as a teacher. He recognizes that the student should acquire something besides simple manual training in this department of education. A want of method, a want of appreciation of the ends to be gained on the part of the teacher, are both fatal to the best results. Mr. A. W. Sanborn, a graduate of the school, is Mr. Foley's assistant.

A report from Mr. Foley accompanies Professor Runkle's paper. From it the following statements are taken:

"The system of apprenticeship of the present day, as a general rule, amounts to very little for the apprentice, considering the length of time he must devote to the learning of his trade. He is kept upon such work as will profit his employer, who thus protects himself. If the apprentice should be thoroughly taught all branches in the shortest time, he would be likely to leave as soon as he could do better, letting his employer suffer the loss of time devoted to his instruction.

"Now, it appears like throwing away two or three years of one's life to attain a knowledge of any business that can be acquired in the short space of twelve or thirteen days by a proper course of instruction. The dexterity that comes from practice can be reached as quickly after the twelve days' instruction as after the two or more years spent, as an apprentice, under the adverse circumstances spoken of above. The plan here is to give to the student the fundamental principles in such lessons as will teach them most clearly, and give practice enough in the shortest time to acquire a knowledge of the different kinds of tools and various ways of using them. For instance, if a man can make a small article in iron, steel, or any other material perfectly by such methods, he can make it of larger proportions with the additional time and help required for such an undertaking. The same in degrees of heat required for fusing or welding metals: if he can do it well in a lesser degree, he can certainly do so in a greater, with the additional facilities.

"After nearly five years' experience in the workshops in my charge, with the valuable suggestions of the professors so much interested in the success of the school, we find the best results in the time allowed accomplished by the method now in use in the institute workshops, viz, three lessons per week of three hours each.

"The time is just sufficient to create a vigorous interest without tiring; it also leaves a more lasting impression than by taxing the physical powers for a longer period. We have tried four hours a day, and find that a larger amount of work and of better quality can be produced in the three-hour lessons.

"In order to give each student the proper credit and to show him the most important points in each piece, the following method has been adopted for inspection. Take case of bending, the points to be noted by the student are rated as follows:

Dimensions	25
Form	70
Finish	5
	100

"The most important point in this lesson is the form, the next the dimensions, and the last the finish. Through all the iron working and other metals in each shop the same method is carried out. Every piece is made to certain dimensions laid down upon the drawing. The object of working to dimensions is to establish the necessity of correctness in measurement, and is followed throughout the course as a very essential point. The most of the exercises convey the idea of the necessity of straight lines in drawing or lengthening iron and graceful curves in bending."

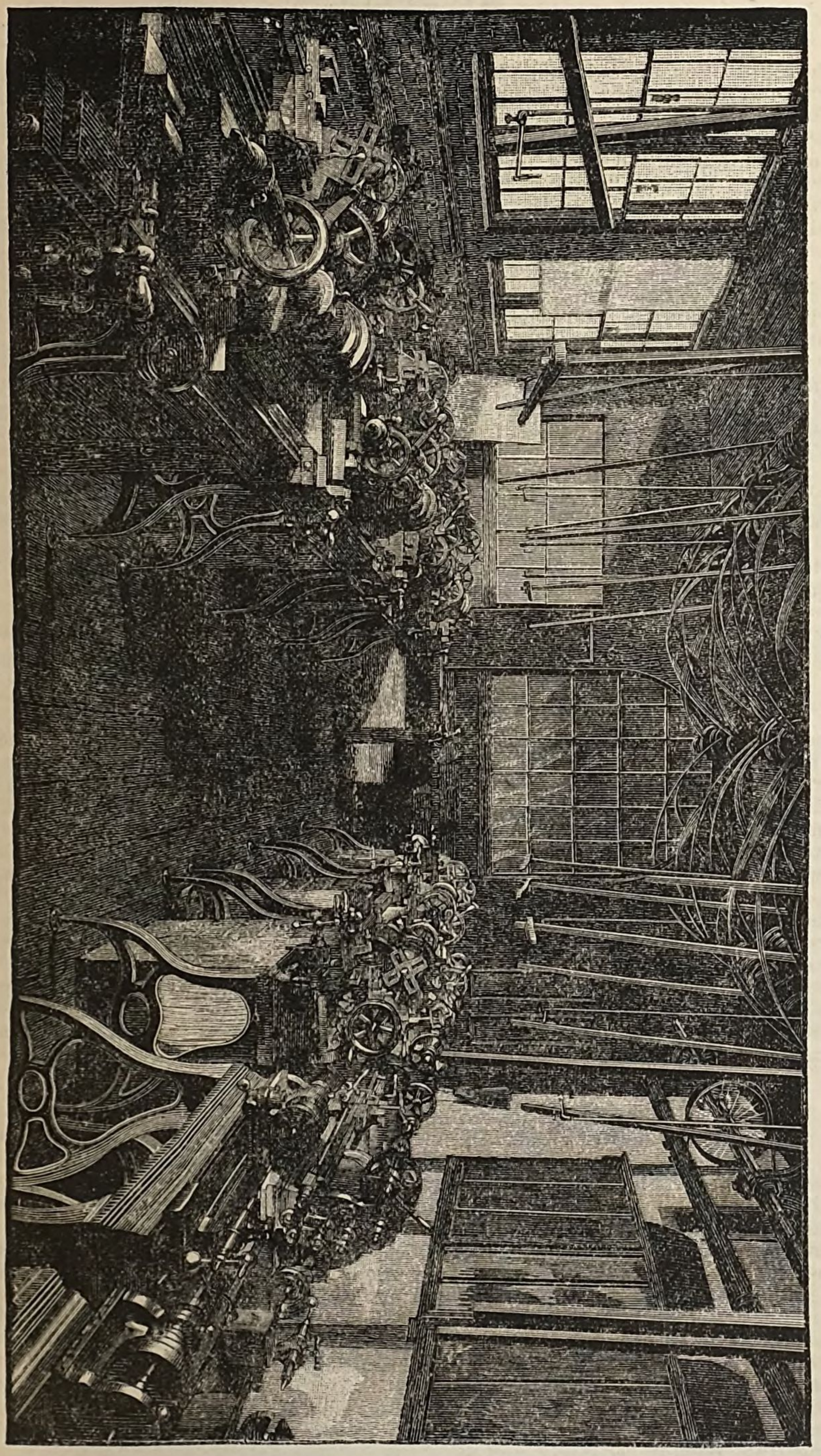


FIG. 9.

THE MACHINE TOOL SHOP.

MICHIGAN.

STATE AGRICULTURAL COLLEGE.

The constitution of Michigan, adopted in 1850, directed the legislature to encourage agricultural improvement and to provide for the establishment of an agricultural school. In obedience to this direction, the legislature in 1855 authorized officers of the State Agricultural Society to select, subject to the approval of the State board of education, a site near Lansing for the school, and to purchase for it not less than five hundred, nor more than a thousand, acres of land. It appropriated twenty-two sections of salt spring lands, or the money arising from their sale, for the purchase of land, erection of buildings, and the payment of necessary expenses. Few months passed before a site three miles from Lansing was selected and the erection of buildings commenced. In May, 1857, the college went into operation. It then had a faculty of six and sixty-one students. During the first years of its existence the institution underwent severe trials. The buildings had been poorly constructed and needed expensive repairs. The price of building and furnishing materials was unexpectedly high. Efficient agricultural instruction could not be afforded. The question whether the institution should continue to afford a general education or be so modified as to give professional training alone was earnestly debated until in 1859 the advocates of the latter idea were victorious. The course of instruction was cut down from four years to two. The professors resigned and discontent prevailed.

In 1861 a State board of agriculture was created for the management of the State Agricultural College. The board consists of six appointed members, and the governor of the State and the president of the college members *ex officio*. The appointed members receive their appointment from the governor of the State and are confirmed by the senate. One-half of them must be practical farmers. Their term of service is six years, two going out of office every second spring.

The course of study is four years in length, and embraces agriculture in all its departments, the sciences on which agriculture depends, and the elements of a general education such as citizens of the State ought to possess. Foreign languages are not taught.

ENDOWMENT AND FUNDS.

The endowment of the college arises from the sale of lands donated to the State for that purpose by the United States. The total number of acres of land given to the State was 235,673.37 acres. The number of acres sold up to September 30, 1882, was 100,-203.50. The number of acres remaining unsold, and held for sale at $5, was 135,469.87.

The fund from the sale of these lands is held by the State as a trust fund for the institution, and the State pays 7 per cent. interest on it, quarterly, into the treasury of the college. The State also collects 7 per cent. interest on the amount due from purchasers, and pays that also quarterly into the college treasury.

The legislature each biennial session makes such appropriations for buildings, improvements, and current expenses as it sees best. The appropriations for 1881 and 1882 amounted to $67,164.

The grounds and buildings are valued (October 1, 1882) at $240,928. The inventory of all the property, not including lands for sale and the endowment funds, is (September 30, 1882) $338,471.55, being an increase in two years of $64,091.49. The annual current expenses amount to $29,000. The annual expense of teaching staff is about $21,000.

FACULTY.

The faculty as laid down for 1883 is composed of professors of mental philosophy and logic, chemistry, zoölogy and entomology, botany, horticulture, mathematics and civil engineering, practical agriculture, and English language and literature, history and political economy, a librarian, assistants in chemistry, in mathematics, in agricultural experiments, and in horticultural experiments, a lecturer in veterinary, a florist, a steward, the foreman of the farm and of the horticultural department, an instructor in military science and tactics, and the secretary of the State board of agriculture. The president of the college is professor of mental philosophy and logic. Nearly all of the professors have charge of some auxiliary department of the institution. One is farm superintendent, another the superintendent of the horticultural department, another in charge of experiments in sorghum, another of surveys and repairs in iron; others are in charge of museums and the laboratories.

Additional work is performed by the professors and their coadjutors in conducting farmers' institutes, six each winter, in different parts of the State, at which topics relating to agriculture, domestic economy, and social life are discussed.

STUDENTS AND THEIR EXPENSES.

The number of students in attendance in 1881–'82 was 216. Of these 2 were resident graduates, 29 seniors, 31 juniors, 56 sophomores, 81 freshmen, and 17 special students. Less than 5 per cent. of the students were women.

Matriculation, incidental, laboratory, and graduation fees are charged, but tuition is free. The rent of heated rooms is $3.50 a term for each student. Board is furnished at cost in the college boarding hall, where all students are required to board. The average price of board for the year 1881–'82 was $3.05 a week.

Students receive remuneration for most of their labor in the quarterly settlement of accounts at a rate depending on their ability and fidelity, the maximum being eight cents an hour.

GRADUATES.

The completion of the full college course entitles the student to the degree of bachelor of science. The number of graduates, up to and including 1881, was 244, of whom 230 are living. One hundred and forty-three are engaged in pursuits related to industrial arts. Among these are 96 farmers, 16 instructors or professors of agriculture or allied sciences, 7 engineers, 6 horticulturists, 6 machinists and mechanics, 3 fruit culturists, 2 agricultural editors, 2 housekeepers, 2 artists, 2 in United States Signal Service, and 1 printer. Of the remainder 24 are business men (mercantile), 24 lawyers or students of law, 17 physicians or students of medicine, 14 teachers or general students, 3 ministers or students of theology, 2 editors, 1 a lecturer, and 2 not reported.

Thus it appears that about 60 per cent. of the graduates are employed in industrial labor. The interest taken by the alumni in each other and in their alma mater is evidenced by the fact that 86 graduates came back to enjoy the reunion of August 16, 1882, though many of them resided in distant States.

INSTRUCTION.

The college year is divided into three terms of nearly equal length. A vacation of about three months intervenes between the autumn term and the spring term. This arrangement enables students to employ the winter months in teaching and be present at the college during the time of the most important farm labor. Instruction is given daily, Saturdays and Sundays excepted.

Elementary chemistry is taught by lectures during the first term of the second year, organic chemistry during the second term, each student being employed daily in blowpipe analysis. The same class studies analytical chemistry three hours a day during the third or summer term. The juniors have lectures during the autumn in agricultural chemistry; during the spring term they study chemical physics; and in the summer term they hear lectures on meteorology. Further instruction is frequently given, the above being a minimum amount.

The study of botany is commenced in the summer term of the freshmen year and continued into the autumn term of sophomore year. It is resumed senior spring, two or three hours of laboratory practice with the compound microscope being had daily for six weeks. A three months' course of lectures on horticulture is given to the juniors, and a half term each of landscape gardening to the juniors and seniors. Practical instruction is given the juniors in connection with their three hours' daily labor in the horticultural department of the college during the entire year.

Entomology, zoölogy, anatomy, physiology, veterinary science, and geology occupy four terms in the junior and senior years. Students have practice in the management of the apiary and the opportunity of dissecting and other laboratory work for two hours daily for one term, an opportunity of which they generally avail themselves.

In practical agriculture the subjects of drainage and breeds of cattle occupy one term of the freshmen year. Lectures are given during one term of senior year on stock breeding, and the principles of general husbandry and of special systems of husbandry. Many of the scientific principles of agriculture are taught by the professors of chemistry and botany. Students receive practical instruction in agriculture during their hours of daily labor throughout sophomore year.

The students receive instruction in rhetoric three terms and in history one term in the freshman and sophomore years. Higher rhetoric (conviction and persuasion) occupies a term in the junior year, and English literature another. Class readings in Shakspere and Milton and in masterpieces of senatorial discussion, in voluntary classes, under instruction, are of continual occurrence. Instruction is given to the seniors one term in psychology, one-half term in moral philosophy, one term in logic, with special attention to induction, one term in political economy and political philosophy, and one-half a term in the constitution of the United States.

APPLIANCES AND APPARATUS.

The college is located on a farm of 676 acres, in which are included swamp lands, pasture lands, fields in rotation of crops, orchards, vineyards, an arboretum, fruit, vegetable, and botanical gardens, a wild garden of native and foreign plants growing on rocky soil, and a park of eighty acres. The farm has cattle, sheep, and pigs of various breeds, and buildings for the protection of stock and the storage of farm produce.

The mechanical department has a carpenter's shop and a blacksmith's shop. There is also a museum of mechanical inventions, illustrating most of the industrial arts, especially agriculture, manufactures, architecture, and engineering. It is intended to enlarge this department greatly another year, and to appoint a professor of practical mechanics.

The botanical department has a laboratory containing the study of the professor of botany, a lecture room, a drying room, a store room, the Cooley herbarium of about 20,000 plants, a museum of vegetable products, and about thirty compound microscopes. A green-house of seven rooms contains a choice collection of the best ornamental plants and of those used in the arts. The botanic garden, the arboretum, beds of grasses, and the labeling of trees and shrubs in the park furnish further facilities for botanical study.

The chemical laboratory has a lecture room for 150 students, analytical rooms fitted with evaporating hoods and tables for 68 students, the professor's private laboratory and study, and rooms for researches in higher chemistry. It contains the chemical apparatus and stores, apparatus for illustrating chemical physics, and a full set of instruments for meteorological observations.

The zoölogical laboratory contains a lecture room for 80 students, rooms for anatomical study and histological work, and a private study.

A general museum contains the usual variety of collections. The library has more than 6,000 bound volumes exclusive of duplicates, and the reading room is supplied with 100 periodicals.

A VISITOR'S REMARKS.

The distinctly agricultural character of the college has attracted much attention, excited many comments, and induced many students and promoters of agricultural education to visit it. Hon. W. H. Ruffner, of Virginia, did so, when inspecting institutions for industrial training, in obedience to the request of the board of visitors of the Virginia Agricultural and Mechanical College. The following paragraphs make up the body of his report:

"The farm contains 676 acres. This includes the ample grounds about the building, which are used for instruction as well as ornament. The barns are large, well planned, and well stocked with horses, cattle, sheep, and hogs, and are kept astonishingly clean. There are six breeds of horned cattle, four of sheep, and four of hogs. But as heretofore intimated, the plan now determined is to breed only one variety and buy samples of others for study. The short horns are the favorite cattle everywhere. I saw a short-horn heifer at the college for which $1,000 had been paid. The Duchess and Oxford families are preferred, and yet the Rose of Sharon cattle are highly spoken of. * * *

"Besides these appliances there are an apiary, a green-house, flower garden, sample grounds for trees, hedge plants, herbs, grasses, and clovers; also gardens of small fruits and orchards; also a botanical laboratory containing lecture room, drying room, herbarium, and museum of vegetable products. This is close to the gardens and grounds. Besides these are other laboratories and museums and a library and reading room. The buildings of this, as of the colleges generally, are large, handsome, and well furnished. The discipline of the institution is managed chiefly by the students themselves.

"The afternoons of five days in the week are devoted to labor by the entire body of students, 232 in number. Dinner at the college boarding-house is at 12. At 12.45 the students report at the tool rooms for orders. Every one who receives an implement is charged with it, and must return it clean and otherwise in good order. The body is divided off into squads, each squad under a leader, who may be one of the senior students. At 1 o'clock they go to work, and are kept busy until four.

"Driving into the grounds through a self-opening gate, I first passed through a gang of students paving the gutters. Next I came to a gang engaged in a very heavy and disagreeable job of ditching and under-draining the lawn. Another party was working in the botanical garden. A large party was husking corn, another cleaning off new ground, &c. Generally they were stout, cheerful fellows who were neither afraid nor ashamed of work, and who are said to become much interested in their jobs, and never to complain so long as their bosses will lay hold and work with them.

"As to compensation for labor, the principle here is the same as elsewhere, and is the plan likely to prevail—namely, to require unpaid labor when strictly under instruction, and for the rest graduated pay, according to the kind of work and the skill and industry of the worker."

MINNESOTA.

THE STATE UNIVERSITY.

The University of Minnesota is located in Minneapolis, on the east side of the Mississippi River, about one mile below the Falls of Saint Anthony, on an elevated bluff overlooking the thriving city and the falls. Its site had been acquired as early as 1857, and a building commenced. Financial disturbances and the effects of the war prevented the opening of the institution, and its practical organization was delayed until the legislature of 1868 passed an act to reorganize the University of Minnesota and to establish therein colleges of agriculture and of the mechanic arts. The act stated that the object of the university "shall be to provide the means of acquiring a thorough knowledge of the various branches of literature, science, and the arts, and such branches of learning as are related to agriculture and the mechanic arts, including military tactics and other scientific and classical studies." A faculty consisting of a president and eight professors was formed in 1869, and the first college class organized in September of that year. A preparatory department had been opened two years before. The same privileges are extended to women as to men.

ENDOWMENT AND FUNDS.

When, in 1849, the Territory of Minnesota was created, two townships of public lands (46,000 acres) were set apart for the endowment of a university. When the Terrritory became a State in 1857 two more townships were added, and the grant of 1862 (120,000 acres) was retained for the university. Thus it had 212,000 acres at its disposal. That which has been disposed of has sold at good rates. The price obtained for the earlier sales of agricultural college land was $5.62 an acre. The regents of the university have no control of the lands. They are in charge of the State land commissioner, who is also State auditor. He is required by the law to manage them as he does the State school lands. The annual income from them is received by the regents from the State treasury.

The financial condition of the university in 1881 was:

Value of grounds, buildings and apparatus	$220,000
Amount of productive funds	575,000
Income from productive funds	35,000
Receipts from the last year's State appropriation	23,000

FACULTY.

The officers of instruction in 1881–'82 were the president, who is instructor in political science, and professors of mathematics and astronomy, chemistry, geology, mineralogy and biology, English language and literature, German language and literature, French language and literature, Greek language and literature, mental and moral philosophy and history, rhetoric and elocution, public health, military science, engineering, and theory and practice of agriculture; assistant professors of Greek and mathematics, and of Latin, and instructors in English and German, vocal music, practical horticulture, field work and drawing, and shopwork, and physics.

Students in 1881–'82.

College or department.	Class.	Gentlemen.	Ladies.	Totals.
Science, literature, and arts	Senior	18	14	32
	Junior	8	7	15
Mechanic arts	Senior	.....	.....	.....
	Junior	4	.....	4
	Special	14	.....	14
Agriculture	Senior	1	.....	1
Collegiate department	Sophomores	39	11	50
	Freshmen	25	8	33
	Subfreshmen	44	27	71
	Special	24	9	33
Total		177	76	253

There are also 9 candidates for masters' degrees, 42 attending summer school of science, 51 attending evening drawing school, and 191 attending the farmers' lecture course. The grand total of students is, therefore, 546.

The only university charge is an annual fee of $5 required of regular students for incidental expenses.

GRADUATES.

The degrees which have been conferred in course up to and including 1882 are as follows: Master of arts, 3; bachelor in arts, 56; bachelor in science, 58; bachelor in literature, 34; bachelor in civil engineering, 8; bachelor in mechanical engineering, 1; bachelor in architecture, 1; bachelor in agriculture, 1; total, 162. Nine persons have taken two degrees.

The whole number of women who have been graduated is 42, viz: 6 B. A.; 14 B. S.; 22 B. L.

A statement of the occupations of 74 graduates was made in 1882. Of that number 31 were teachers, 26 lawyers, 8 farmers, 11 physicians, 10 ministers, 8 manufacturers, 9 merchants; and there were in banking, 2; journalism, 3; milling, 2; mining, 2; library work, 3; building, 2; real estate, 3; engineering, 4; 2 were naturalists; 1 an architect; 1 a government clerk, and 1 a florist. Seven ladies were married. Those who leave before graduating return usually to the employments they formerly pursued, and as half the students are farmers' sons, many return to a farmer's life.

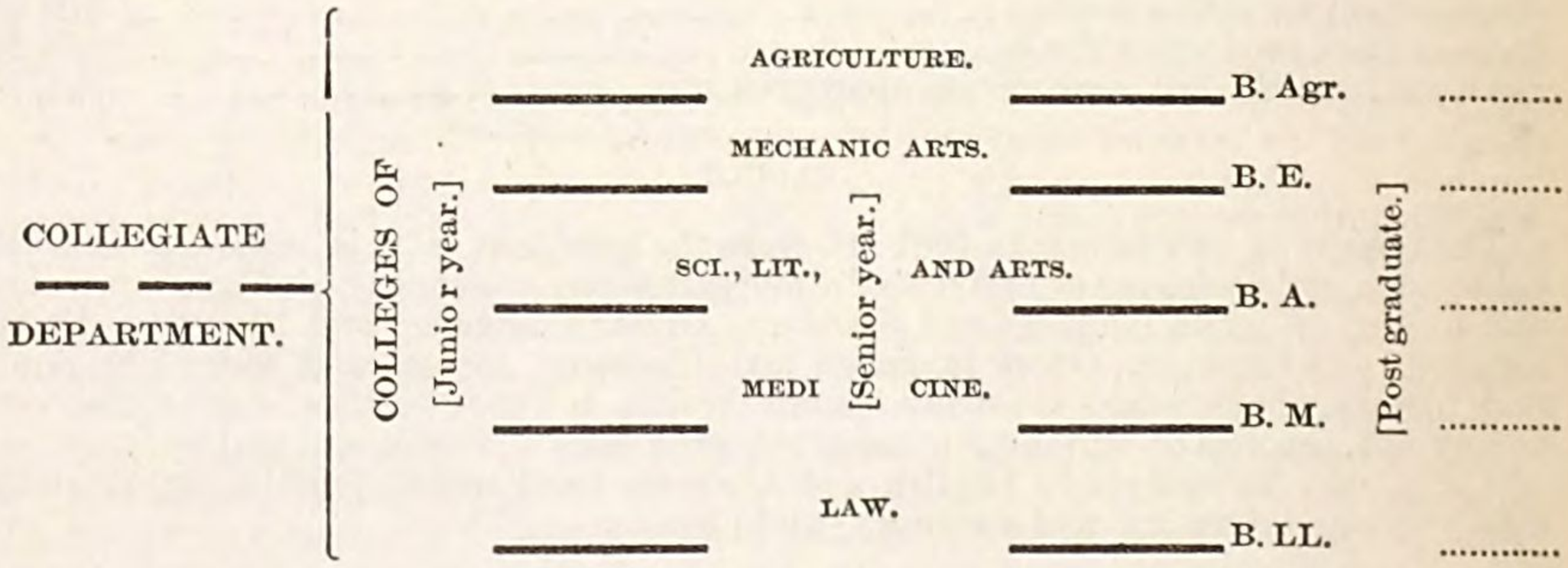
GENERAL PLAN OF THE UNIVERSITY.

Under the organic law the board of regents are authorized to establish *any* desired number of departments or colleges, the following, however, being specified:

A department of elementary instruction.
A department of science, literature, and the arts.
A college of agriculture.
A college of mechanic arts.
A college or department of medicine.
A college or department of law.

The colleges of law and medicine have not yet been organized.

The relative position of these colleges or departments is illustrated by the following diagram:



COLLEGIATE DEPARTMENT.

The department of elementary and collegiate instruction, known for short as the collegiate department, is introductory to the permanent colleges of the university. It includes that part of the preparatory department which is retained, and two years of the usual collegiate work. The following remarks on this plan of organization appear in the calendar of 1881–'82:

"This arrangement of departments emphasizes and formulates the growing tendency and custom of American colleges and universities to make the close of the second or sophomore year a branching point for the introduction of optional studies and for certain professional or technical courses. It presupposes a separation of the secondary and superior epochs of education, and a corresponding assortment of studies. The high schools and other fitting schools of the State are thus invited to extend their work substantially up to the junior year. When at length this shall have been generally done, the university will, as provided by law, dispense with the whole of the department of elementary instruction, and will extend her work on post graduate ground. Among the advantages claimed for this general plan may be named the following:

"1. A faithful adherence to the letter and spirit of the laws, State and national, which have established and endowed the university, and which contemplate it as a federation of literary, professional, and industrial colleges, having each its own organization, faculty, buildings, and equipment.

"2. That while offering the old college curriculum and discipline in their best forms to the literary and professional classes, the university will provide for the industrial classes that 'liberal and practical education' required by law and public sentiment.

"3. The separation of the natural epochs of secondary and superior education, and the ultimate liberation of the university from the elementary work of the former; and, coinciding with this division, an advantageous assortment of studies, methods, and discipline suitable to the two periods respectively.

"4. A close and vital articulation of the university with the public school system of the State; the elevation of the high schools by enlarging the recognized sphere of their instruction.

"5. The elevation of the professional schools by requiring of candidates for degrees a good general education as a prerequisite for admission, while not insisting upon the impossible condition that all shall have gone over the whole of the old college course.

"6. The elevation in particular of the colleges of agriculture and mechanic arts to equal rank and standing with other university courses, and the separation of the studies and exercises properly belonging to them from the elementary branches taught in primary and secondary schools."

There are three courses of study in the collegiate department, (1) classical, (2) scientific, and (3) modern. The requisites of admission common to all courses are arithmetic, elementary algebra, plane geometry, geography, history (United States and general), physiology, and either English grammar or Latin grammar. The additional requirements for the classical course are Greek grammar, three books of Cæsar, and two orations of Cicero; for the scientific course, physical geography, the elements of astronomy and physics, and either English history and English composition and word analysis, or the Latin for the classical course; for the modern course, composition, word analysis, English history, and either the scientific or the Latin subjects mentioned.

All successful examinations on entrance studies in the high schools under the State high school board are accepted in lieu of entrance examinations at the university.

The work of the classical course is mostly confined to the ancient languages, mathematics, and the elements of science. The modern course has chiefly to do with modern languages (German and French), mathematics, sciences, and English or Latin studies.

The scientific course is distinctly preparatory to the colleges of agriculture and mechanic arts. The required studies of sub-freshman year are, first term, elementary chemistry, ancient history; second term, drawing, algebra; third term, botany, geometry, English studies. German and Latin are optional studies throughout the year. Drawing and higher algebra, physics, trigonometry, and mediæval history, and general chemistry, botany, and surveying are the required studies of the three terms of freshman year. The optional studies are of the same nature as those of the previous year. In sophomore year French is substituted for German in the optional list; and the required studies are, first term, applied chemistry and physics; second term, descriptive geometry, rhetoric, and analytical chemistry; third term, zoölogy, conic sections, history (modern), and analytical chemistry.

The members of the subfreshman class and all students lately admitted are required to attend courses of lectures as follows: (1) On the use of the library, and on their relations to the university, to be delivered by the president, in alternate weeks during the first term of each year; (2) on books and reading, by the professor of English, in alternate weeks during the second term; and (3) on health and hygiene, by the non-resident professor of public health, in alternate weeks during the third term. Each student must have as a general rule three recitations a day (fifteen a week), besides rhetorical, military, and other exercises.

COLLEGE OF AGRICULTURE.

Instruction in agriculture and the sciences relating thereto is imparted through the following channels:

1. An elementary course to such as may choose it upon entering the university, which affords special technical instruction from the beginning.
2. The regular undergraduate course, which is open to those who have pursued the elementary course or one of the courses of the collegiate department.
3. Special courses of one, two, or three terms, which may be pursued without any entrance examinations.
4. A farmers' lecture course, for admission to which no fees, examinations, or other conditions are imposed.
5. Labor of students upon the farm, which though done primarily for pecuniary gain does not fail to impart manual skill and a knowledge of better methods, together with some theoretical insight.
6. The publication of the results of experiments which have been pursued.

The elementary course agrees in the main with the scientific course of the collegiate department, differing from it chiefly in the substitution of natural sciences and practical

instruction for a portion of the mathematics and languages. Students are admitted to it on the same conditions and are required to engage in the same general exercises. During their course they have sufficient practice on the farm and in the garden to give them skill in the different operations. The prescribed studies of sub-freshman year are algebra, mechanical drawing, elementary chemistry, elementary botany, how crops feed and grow, and English studies or German. Freshman year: Soils and manures, farm crops, general chemistry, physics, botany, drawing, and English or German. Sophomore year: Horticulture, practical agriculture (farm animals), applied chemistry, analytical chemistry, meteorology, climatology, zoölogy, and English or French.

The regular undergraduate course is as follows:

Terms.	Junior year.	Senior year.
I	Composition and physiology of plants—How Crops Grow. Horticulture Mechanical physics, or other elective.	Practical agriculture—soils and fertilizers. Comparative anatomy and physiology. Geology, or other elective.
II	Agricultural chemistry. Mineralogy and chemistry. Mineralogy, or other elective.	Practical agriculture—farm crops. Veterinary medicine and surgery. Civil government, or other elective.
III	Atmosphere and soils—How Crops Feed. Horticulture. Psychology, or other elective.	Practical agriculture—farm animals. Economics—"Accounts, markets, &c." Political economy, or other elective.

The special courses in agriculture are arranged for three terms, each of which may be taken separately. They are as follows:

First term.—Agricultural chemistry, how crops grow; agriculture, soils and manures; horticulture, fruits.

Second term.—Agricultural chemistry, how crops grow; agriculture, farm animals; arboriculture.

Third term.—Farm drainage and accounts; agriculture, farm crops; horticulture, vegetables.

The scope of instruction in agriculture can be understood more clearly by presenting some of the important topics included under the general headings given above.

In *agricultural chemistry* a study is made of the elements of the volatile parts of plants, as carbon and oxygen; of the organic compounds of plants, as water, starch, and sugar; of the elements of the ash of plants and their compounds, as potassium, calcium, iron, sulphates, and phosphates; and of the atmosphere and the soil as related to vegetation and as sources of food to plants. A course in the analysis of soils, fertilizers, grains, and fodders is taken.

In *horticulture* subjects of study are relations of heat, light, moisture, and food to plant growth, and the means of controlling their supply and intensity; plant-houses and hotbeds; soils and manures and their manipulation; propagation of plants; grafting, budding, pruning, and training; planting and transplanting; hybridizing, crossing, and selecting; cultivation of fruits; kitchen, market, and landscape gardening and floriculture.

In *arboriculture* the reasons for planting forest trees are considered, as are also the kind of trees to plant, methods of propagating, care in the nursery, and special culture of each species.

In *practical agriculture* the topics are the history of agriculture; composition, classification, properties, peculiarities, treatment, and adaptations of soils; reclamation and improvement of soils, including drainage, subsoiling, trenching, tillage, &c.; road making and fencing; manufacture, preservation, and application of manures and stimulants; green manuring and irrigation; farm implements and machinery; production, management, and sale of crops; the different breeds of domestic animals, their characteristics and adaptations, breeding, rearing, feeding, and management; selection and purchase of farms; and the location, construction, and arrangement of farm buildings.

The students in agriculture have the benefit of the library and apparatus of the university. Of these appliances the museum of agriculture, the plant-house, and the farms belong especially to the College of Agriculture.

The *museum of agriculture* contains models of agricultural implements; seeds of garden vegetables, grasses, grains, and noxious weeds, in jars; grains and grasses in the straw; drawings and lithographs of machines; fruits in alcohol; woods, from the United States Department of Agriculture; and miscellaneous objects and materials used in agriculture.

The *plant-house*, covering an area equal to 34 by 45 feet, supplies plants and flowers for the study of botany and the apparatus of instruction in the propagation and care of plants.

The *experimental farm* has been divided up by the extension of the city and the construction of a railroad, and consequently is unfitted for advantageous use. A new farm of 155 acres has been procured, which is said to be one of the finest pieces of land in the State.

A fruit farm is under the care of the regents. Upon it experiments chiefly in acclimatization are being tried.

The farmers' lecture course is specially designed to meet the wants of farmers and others who desire practical and scientific information on agricultural subjects, and who cannot devote an entire year to study. The *scientific* instruction includes agricultural chemistry, botany, physiology, entomology, geology, and mechanics. It is given by the professors who have these departments in charge in the university. The practical instruction includes the improvement of soils by drainage, subsoiling, trenching, plowing, rotations, manures, grain raising, dairying, fruit culture, forestry, farm accounts, and rural architecture. This instruction is given by the professor of agriculture and by men who have become successful and noted in these special departments. One hundred and ninety-one persons, many of them from distant parts of the State, were registered in the course given in February, 1882. A large additional number were in occasional attendance. The course was opened by a valuable address by Hon. George B. Loring, United States Commissioner of Agriculture.

THE COLLEGE OF MECHANIC ARTS.

The aim of the instruction given in the College of Mechanic Arts is to lay a broad and solid foundation in mathematics, mechanics, and drawing, so that, with the practice in field, shop, and office work, students shall be fitted for immediate usefulness upon graduation, and after a moderate amount of subsequent practice and experience be capable of taking charge of important works.

There are five courses of study, three regular and two special. The regular courses are in mechanical engineering, civil engineering, and architecture; the special, in shop work and drawing, and in mechanical drawing, an evening course. Students are admitted to the last two courses if deemed competent by the professors giving instruction. Applicants for admission to the regular courses must either have completed the scientific course of the collegiate department or be examined in its studies.

The course in civil engineering is as follows:

Junior year.—First term: (1) Curves, leveling, and earthwork; (2) analytical geometry; (3) history of civilization and comparative philology or other elective; (4) field work and drawing. Second term: (1) Mechanics (statics); (2) differential calculus; (3) mineralogy; (4) drawing (descriptive geometry). Third term: (1) Mechanics (statics) and strength of materials; (2) integral calculus and theory of equations; (3) English literature, or other elective; (4) topography and drawing.

Senior year.—First term: (1) Arches, retaining walls, and hydraulics; (2) stereotomy; (3) geology or astronomy; (4) railroad work and drawing. Second term: (1) Roofs, trusses, and lectures on motive power; (2) practical physics (testing strength of materials); (3) civil government, or other elective; (4) drawing. Third term: (1) Designs and specifications; (2) practical astronomy; (3) political economy, or other elective; (4) drawing on designs.

The course in *mechanical engineering* differs from that in civil engineering in the following particulars:

1. Shop work is offered every term except the last, and field and railroad work is omitted.
2. In the junior year elements of mechanism is substituted for curves, leveling, and earthwork, and dynamical mechanics for statical.
3. In senior year machinery takes the place of arches, retaining walls, and hydraulics; applied descriptive geometry, the place of stereotomy; and steam engine, the place of roofs, trusses, and lectures on motive power.

The course in *architecture* coincides with that in civil engineering except as follows:

1. The drawing throughout the course is especially arranged for architecural work.
2. In the first term of the junior year history and orders of architecture are substituted for curves, leveling, and earthwork.
3. In the second term of the senior year lectures on decoration and color are substituted for lectures on motive power.
4. In the third term senior year the designs and specifications are those of buildings instead of bridges, &c.

The course in *shop work, drawing,* &c., is intended to give a thorough drill in the use of tools, teaching methods and processes common to different trades, and also a practical working knowledge of drawing and such branches of mathematics as may be studied. It is one year in length. Instruction in drawing and mathematics is continued throughout. Vise work is undertaken in the first term, forge work in the second, and wood work in the third.

This course has been rendered possible by the equipment of shops for the practical work of the course in mechanical engineering. These shops are three in number, and each has its room in the basement of the Agricultural College building. (1) The vise shop contains two benches, with double sets of drawers, so that thirty-two students can be accommodated in two reliefs. It has ten vises and the necessary tools for giving instruction and practice in chipping and filing. (2) The forge shop is provided with eight forges and anvils and the tools required for the manipulations of the blacksmith, a six-horse power engine, and the usual accessories of such a shop. (3) The wood shop contains benches and vises sufficient for accommodating thirty-two students in two sections. Shops for instruction in the use of machine tools and in foundery work will be equipped when the building for the college of mechanic arts is completed.

An evening course in *drawing* is arranged for the winter of 1882–'83, consisting of twenty-five lessons. Those who have received instruction in drawing are given advanced work. Beginners first receive instruction in geometrical and projection drawing; afterward the work is varied as far as possible to meet individual requirements.

COLLEGE OF SCIENCE, LITERATURE, AND ART.

The College of Science, Literature, and the Arts is intended to furnish higher courses of liberal studies, leading to the customary academical degrees. Accordingly there are classical, scientific, and modern courses. About one-third of the work of each is prescribed, two-thirds elective. The studies of the courses are as follows:

JUNIOR YEAR.

First term.—Required: In the classical course: Greek—Homer; in the scientific course: Physics—mechanics; in the modern course: German—Gœthe. Elective: History of civilization, comparative philology, analytical chemistry, analytical geometry, zoölogy.

Second term.—Required: In the classical course: Latin—comedy; in the scientific course: Mineralogy; in the modern course: German—Lessing. Elective: Psychology, differential calculus, analytical chemistry, and theoretical chemistry.

Third term.—Required: In all courses: English literature. Elective: Logic, integral calculus, analytical chemistry, Latin (philosophy), German (literature).

SENIOR YEAR.

First term.—Required: in all the courses: Geology. Elective: History of philosophy, English literature (British and American oratory), analytical chemistry, astronomy, French.

Second term.—Required: In all the courses: Ethics. Elective: Civil government, French, analytical chemistry, economic geology, sanitary science, international law.

Third term.—Required: In all the courses: Political economy. Elective: Practical astronomy, French, analytical chemistry, English literature, natural theology, anthropology.

The instruction closes with the tenth week of the term; the examination takes place in the eleventh week.

DEGREES.

The completion of the classical course of the College of Science, Literature, and the Arts entitles the student to the degree of bachelor of arts; of the scientific course, bachelor of science; of the modern course, bachelor of literature. The courses of the College of Mechanic Arts lead, respectively, to the degrees of bachelor of civil engineering, bachelor of mechanical engineering, and bachelor of architecture; that of the College of Agriculture, to bachelor of agriculture.

The degrees of civil engineer, mechanical engineer, and architect will be conferred upon those who have received bachelor's degrees in those callings who shall, not sooner than two years after attaining a first degree, pass a satisfactory examination on (1) some special professional subject and (2) any three subjects on a prescribed list, and shall present a design and a thesis.

On similar conditions, the furnishing of a design excepted, masters' degrees in science, literature, and arts are conferred. The examination of the candidate for the degree of master of arts is upon two classical authors (Latin and Greek) and on three subjects chosen from a list. The characteristic subjects of examination are two distinct branches of natural or physical science for candidates for the degree of master of science; two modern authors (German or French) for the candidates for a master's degree in literature. These candidates must also undergo examination upon three other subjects chosen from a list, and all must submit a thesis.

BUILDINGS AND APPLIANCES.

The general plan of the university buildings contemplates a central academic building, and grouped around it additional structures for the separate departments or colleges. The main edifice and the agricultural college building have been erected, and an appropriation aggregating $180,000 is intended to supply a farm-house, a building for the College of Mechanic Arts, a military building (including a gymnasium), an astronomical observatory, a museum, and a library.

The main or academic building is built of blue limestone, is 186 by 90 feet, and three stories in height. The rooms, 53 in number, as well as the corridors, are heated by steam and thoroughly ventilated. Water is supplied from the city mains, and is amply available in case of fire.

The *agricultural college* building is a brick structure with a central portion two stories in height and one story wings, in one of which is the chemical laboratory. The other is a plant house. Rooms in the central building are used for recitations in agriculture and chemistry and for the museums of technology and agriculture.

The *chemical laboratory* occupies five rooms, as follows: (1) A large room for students' work, fitted up for 64 persons working in two sections; (2) a smaller quantitative laboratory; (3) an apparatus room; (4) the professor's private laboratory; (5) a room in the basement fitted up for assay and furnace work.

The *physical laboratory* is so arranged and furnished that students desiring to make a specialty of physics can have an opportunity to use the apparatus and perform their own experiments. One of the rooms has been set apart for a lathe and work bench.

The *mineralogical laboratory* is furnished with three double tables, accommodating eighteen students. Each table is provided with all the apparatus and reagents necessary for a complete series of blow pipe tests and for all the qualitative chemical work done in the determination of rocks and minerals. The room is also used for the practical work in zoölogy and botany.

Three of the *museums* of the university have not been described. They are the general museum, the classical museum, and the museum of technology. The general museum contains the collections of the geological and natural history survey of the State, sets of collections of the United States Fish Commission, and a large display of zoölogical specimens. The classical museum is to be composed of material illustrative of classical geography and history, coins and medals, ancient books and manuscripts, specimens of inscriptions, implements of writing, and similar objects of interest. The museum of technology will be composed, among other things, of fuels, ores, furnace products, textile materials, earthenware, and the processes and products of applied chemistry.

The *library* now contains about 15,000 volumes, and is open eight hours a day, Sundays and holidays excepted.

GEOLOGICAL AND NATURAL HISTORY SURVEY.

Among the kinds of work carried on under the supervision of the university which are indirectly educational are the geological and natural history survey of the State and the trial of agricultural experiments. The survey was commenced in 1872, but has been confined principally to geological work. The collection of botanical specimens has recently been ordered, with a view to the creation of a full herbarium of the flora of the State. Systematic observations and reports on the birds of the State have also been commenced. A recent calendar says:

"The law creating this survey is comprehensive. It embraces not only a strictly geological survey, including a complete account of the rocks and minerals of the State and their chemical analysis, but also a natural history survey, comprising an examination of all species of trees, shrubs, herbs, grasses (native or naturalized), and a complete account of the animal kingdom, as represented in the State, including all mammalia, fishes, reptiles, birds, and insects. It also orders the tabulation of meteorological statistics and an investigation of the climatic peculiarities of Minnesota. It orders the collection of topographical and hypsometrical data, and the compilation of an accurate map which, with the approval of the governor, is to be the official map of the State. The law also requires an exhibition made during the progress of the survey, in the building of the university, for public inspection free of cost, in well warmed and furnished rooms. The regents make annual reports of progress, and on the completion of any portion of the work a final report thereof is made to the governor."

FARM EXPERIMENTS.

The experimental work of the university has been extensive, important, and practical. Almost all varieties of garden vegetables have been tested for determining their compar-

ative value and their characteristics. Varieties of corn have been tried with reference to time of ripening and productiveness. Wheat, rye, oats, and barley have been subjects of experiment. Fertilizers, methods of culture, fruit trees, ornamental and forest trees, the working value of implements and machines, and the germination of seeds are also among the matters of experiment. The results of experiments are often exhibited at fairs, and seeds produced are kept for sale at low prices, so that a wide distribution and a careful trial of them are secured.

SUMMER SCHOOL OF SCIENCE.

Courses of instruction in botany, chemistry, and geology were given during July, 1881 and 1882. They were designed to afford teachers and all others interested in the practical study of science an opportunity to become acquainted with the methods of original investigation and of teaching from actual specimens.

The course in botany was substantially as follows: (1) the general histology of plants, five days; (2) the structure of cryptogams, seven days; (3) the structure of phanerogams, six days; (4) the special physiology of the higher plants, several days. The course consisted to a great extent of laboratory work, preceded each afternoon by a lecture.

The lectures in chemistry comprised a presentation of the main points in the modern theories of the science and a review of its practical applications.

The course in geology included (1) a statement of some recent theories in dynamic geology, (2) an outline of historical geology, and (3) lectures on the geology of Minnesota.

Museums, laboratories, and the conservatory were in constant use. A laboratory fee of $1 a week was charged; the lectures were free.

The summer school of 1882 was extended in its scope to embrace rhetoric and elocution, English literature, and the German language.

Over two hundred persons, chiefly teachers, attended. The instruction was given by professors of the university, without extra compensation.

MISSISSIPPI.

THE AGRICULTURAL AND MECHANICAL COLLEGE.

The Agricultural and Mechanical College of Mississippi is located near Starkville, in Oktibbeha County. It was opened October 6, 1880, receiving national aid formerly given to the State University for the endowment of an industrial college as one of its departments. The objects and character of the institution are presented in the first annual catalogue as follows:

"The legislature of Mississippi, in accepting the endowment or trust fund from the general government, prescribed in the powers given to the board of trustees 'the establishment and maintenance of a first class institution at which the youth of the State may acquire a common school education and a scientific and practical knowledge of agriculture, horticulture, and the mechanic arts, also the proper growth and care of stock, without, however, excluding other scientific and classical studies, including military tactics. They shall regulate the course of study, rates of tuition, management of experimental farm, manner of performing labor, and the kind of labor to be performed by students. These two acts of the general and State governments plainly define the objects of the college. The 'leading object' must be to benefit 'agriculture and the mechanic arts.' Should other studies be taught than those relating to these interests they should be considered secondary and rather as instruments to more readily comprehend the sciences which underlie agriculture and the mechanic arts.

"The complexion of the college must be such as to familiarize students with the leading objects as set forth in the acts: to educate and direct their minds and tastes to agriculture, horticulture, care and growth of stock, management of farms, manner of performing labor, and the mechanic arts. The college is not to be, in the strictest sense, either literary, classical, or military, but rather a college intended for special technical training in agriculture and the mechanic arts.

"This necessitates that special stress should be laid on the sciences, such as chemistry, botany, geology, zoölogy, entomology, physiology, mechanics, mathematics, physics, &c., which underlie agriculture, as this is the predominant interest of Mississippi. To understand properly these sciences, a very liberal culture, especially in English, is requisite. The foundation of this liberal culture must be proportionally as systematic and thorough as that required to comprehend what are sometimes called the learned professions. The varied conditions contributing to an intelligent understanding of agriculture as a science

and an art comprehend an education as broad and liberal as that needed in mastering any profession. The education must necessarily, however, differ in kind. Students whose education is intended to promote the interests designated in the acts must omit some studies taught in other colleges looking to general or special trainings. The education, too, is to be practical and industrial; students must be familiar not only with farms and labor, but must also labor themselves, and this labor is a part of their education. It is educational in so far as it is in illustration of studies taught in the lecture or recitation room."

FINANCIAL CONDITION.

The status of the agricultural land scrip fund donated by the United States Government is as follows: The scrip represented 207,920 acres of public land, which was sold for about ninety cents per acre, realizing in currency $188,928. This amount, by judicious management, has been increased to $227,150, which is now in the State treasury, represented by twenty year bonds running from 1876 to 1896, bearing five per cent. interest per annum. This fund, by the terms of the act of the State legislature of February 28, 1878, is equally divided between Alcorn University and the Agricultural and Mechanical College, giving to the college $113,575, or an annual interest of $5,678.75.

With the means furnished by the legislature in their first appropriation for the years 1880 and 1881 ($85,000), they finished the college building, erected a dormitory for 200 students, a president's house, together with temporary barns and stables for stock.

They have bought and partially equipped a farm of 840 acres and paid the expenses of conducting the college for one and one-half years, including pay of the faculty and the partial equipment of the academic and scientific departments.

The recent legislature (1882–'83) has made a most liberal appropriation ($120,000) to put the college on a permanent basis.

The board of trustees now have the means and are proceeding to erect all needed buildings, such as additional dormitory room, a hospital, professors' houses, barns, stables, &c.* Books for library are provided, as also the means to thoroughly equip the scientific, agricultural, and horticultural departments, to exemplify varied and diversified agriculture to the best advantage. The legislature has also given permission to remove from the State capitol to the college the splendid cabinet of minerals and soils illustrating the different sections of the State.

The legislature of the State has indicated its intention, by its acts, of supplementing liberally the means furnished by the general government and to make the college a first-class institution.

FACULTY AND OFFICERS.

The collegiate faculty as now constituted consists of a president, who is the executive officer of the board of trustees, professors of English language and literature, biology, scientific and practical agriculture, scientific and practical horticulture, chemistry and physics, mathematics and civil engineering, military science and tactics, and a tutor of English and mathematics.

This faculty intends to give a practical and scientific knowledge of agriculture and the mechanic arts.

The board of trustees provided also for a preparatory department, which will afford the youth of the State the means of acquiring a thorough elementary education. The faculty of this department consists of a professor in charge and two assistants.

Other persons included in the faculty and officers are the secretary and treasurer of the board of trustees and college, writing instructor, a steward and foreman of the farm.

STUDENTS AND COLLEGE EXPENSES.

Students in attendance the first year numbered 354; during the second year, 304. The session of 1882–'83 opened with nine students in the senior class, twenty in the junior, forty in the sophomore, eighty in the freshman, and eighty in the preparatory department, a larger number than at the opening in either of the previous years. Only those who have older brothers are admitted under fifteen years of age.

Before admission all applicants must submit to an examination. If for the freshman class, they must be thorough in arithmetic, geography, grammar, reading, spelling, and writing.

Students will be admitted into the freshman class or any more advanced class at any time, provided they can stand an examination in all the previous studies of the course.

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*All of the new buildings are about completed, viz: 8 professors' houses, 2 large cattle barns, a mess-hall to accommodate 300 students, engine-house, sorghum mills and evaporators, sub-earth ventilating dairy (in process of construction), and a hospital building. A new laboratory for chemistry is going up, to cost $9,000.

No one will be admitted into the preparatory department unless he is able to read ordinary prose readily, to spell words of common use, to write simple English sentences, and to read and write numbers with facility; he must also be thoroughly acquainted with the four fundamental rules of arithmetic.

A matriculation fee of $5 is required. Tuition is free to residents of Mississippi. Owing to large numbers of applicants no students, at present, are received from other States.

The average cost of board is $9 per month. The college has accommodation for boarding 250 students.

The students wear a neat and serviceable uniform of cadet gray. The annual expense of students (not including clothing and traveling expenses) is from $80 to $125.

Students are required to work on the farm, in the horticultural department, or under the master mechanic for three hours for five days in the week, and are paid 8 cents an hour for the work faithfully performed. They are marked in their work as in their recitations, half work only gives 4 cents an hour. Work on Saturday is not compulsory as during the week, but at the pleasure of the students. Some twenty-five students during the session of 1880–'81, by means of their work, paid all their expenses with less than fifty dollars from outside resources.

INSTRUCTION.

There is a single course of study extending over two years preparatory and four years collegiate. Only common English studies are required in the preparatory department. The collegiate course is as follows:

Freshman class.—Algebra, geometry, outlines of history, English language, natural philosophy, botany, agriculture (lectures), book-keeping, and writing.

Sophomore class.—Geometry, trigonometry, surveying, English language, rhetoric, elementary chemistry (lectures), blow-pipe and wet analysis, organic chemistry (lectures), and agriculture (lectures).

Junior class.—English language and literature, mechanics, mechanical drawing, anatomy and veterinary science, agricultural chemistry, chemical physics, physiology, physical geography, horticulture, and free-hand drawing.

Senior class.—Astronomy, civil engineering, English literature, meteorology (lectures), agriculture (lectures), entomology (lectures), political economy, Constitution of the United States, botany with microscope, moral philosophy, and zoölogy.

Preparatory department course of study.

First year.—Arithmetic (mental and practical), elementary grammar, composition, spelling, reading, writing, and declamation.

Second year.—Arithmetic reviewed, English grammar and composition, geography, writing and declamation, algebra, analysis, and United States history.

The energies of the college are at present centered in agricultural education, as shops and conveniences for instruction in mechanics are not yet supplied. This deficiency is made up by the employment of a first class master mechanic, who has charge of the students inclined in this direction, and they are engaged in building, repairing, and shop work done on the premises.

In the industrial department the farm and horticultural departments are separated, and each is in charge of a professor. The professor of horticulture is now establishing a large commercial nursery for supplying fruit trees to the people of the State. He has also a large garden of 20 acres, which supplies vegetables for the students. The mess hall of over 200 students is a market for sale of supplies from the farm and horticultural department.

The principal topics of instruction in agriculture are the following:

Freshman class, second term.

Instruction is given by lectures, embracing the history, characteristics, breeding, and care of the most valuable breeds of cattle, horses, sheep, and swine; dairying; the feeding and care of the cow; manipulation of the milk in shipping or making into butter and cheese. To illustrate the course of lectures the college is breeding pure and grade Jerseys, Holsteins, Galloway, and short-horn cattle, Merino sheep and Berkshire swine. Other breeds will be added; also a dairy herd of 50 cows. During the present year a model dairy house, with all the appliances for making butter and cheese, will be erected and put in operation.

Sophomore class, third term.

Lectures on the principles of drainage, effect of an excess of water in the soil on the cultivation and growing of crops, contamination of well and cistern water, surface and

subsoil drainage, laying tile and sewers, side-hill ditching, controlling streams, and preventing soil from washing.

Principles and mechanical construction of farm implements and machinery, draught, care of and repairs, with practical instruction in the field in the use of the plow, cultivator, mower, reaper, &c.; also the care of the steam engine, corn mill, evaporator, threshing machine, feed mill and fodder cutter.

The college now owns and is using a complete set of farm machinery and implements, procured from the leading manufacturers of the country.

Senior class, second term.

Lectures on farm economy and management, stock feeding, value of different kinds of food and manures, management and application of manures and fertilizers, composting, green manuring, adaptations of soils to crops, special crops, rotation of crops, different methods of cultivation, planning and erecting farm buildings. The course of lectures is based on the standard agricultural literature of the day and practical experience gained in farming. The instruction, while embracing the theories and sciences relating to agriculture, is practical and will be illustrated by the work of the farm as far as possible. As a means of illustration the college has a farm of nearly one thousand acres, embracing a great variety of undulating land, both fertile and exhausted, with commodious barns and out-buildings, planned with especial reference to exhibit special and mixed husbandry on a sufficiently large scale to enable the student to become conversant with all the details of the business. The crops grown include the different grains, grasses and forage crops, corn, cotton, sugar cane, sorghum, &c., besides experimental plats of all the plants that can be obtained that promise to be of value for any purpose. At present the college owns over two hundred and fifty head of pure bred, grade, and native cattle.

The growing of food crops and their preparation for feeding in an economical manner by cutting, grinding, and cooking, and the feeding of cotton seed and its products, and the making of barn yard manure is one of the special features of the farm department.

The breeding and rearing of the several most noted breeds of stock, both for milk and meat, and experiments in comparative tests in feeding, will acquaint the student with the desirable qualities of the several breeds for various purposes. Nearly all the work of the farm, except driving the teams, is performed by students.

At the close of the course in agriculture, questions pertaining to the details of the entire work of the farm department will constitute a part of the regular required examination.

MILITARY DEPARTMENT.

Few agricultural colleges give as much prominence to military regulations and instruction as does the Agricultural and Mechanical College of Mississippi.

Drills are compulsory on all who are not specially excused by the surgeon, day scholars equally with others. Companies are drilled by student officers, under the supervision of the commandant. Battalion drills take place similarly. Artillery drill is by classes. A new guard is mounted every morning, and there is a parade every day about sundown. In the evening, during study hours, sentinels are posted along the halls of the dormitory to maintain order. At the change of reliefs, each sentinel inspects the rooms on his post to see that no one is visiting, sleeping, or absent without authority.

Members of the guard are not excused from study or recitation because of having been on duty. Just before 10 o'clock sentinels are relieved and all retire, except officers, who inspect at that hour. Early in the morning all students are wakened and immediately attend roll call.

Half an hour later their rooms must be ready for inspection. Then study is required until 7 o'clock, the breakfast hour. In like manner a ceaseless watch is kept over students; and their delinquencies subject them to mild but certain punishments.

The professor of military science and tactics delivers a three months' course of lectures to the senior class on subjects pertinent to his department.

Alcorn Agricultural and Mechanical College.

The fund for the education of the people of Mississippi in agriculture and mechanics is divided equally between the white and colored races. The institution through which the latter race receives the benefit of this is now called the Alcorn Agricultural and Mechanical College, formerly Alcorn University. It is located near Rodney, in Jefferson County, which lies on the Mississippi River, just below Vicksburg. Little has been reported recently from the college, and only a few general facts can be given.

The university was charted in May, 1871; it had been opened some months before. There are collegiate and preparatory departments, each having agricultural and literary courses. The collegiate courses are four years in length; the preparatory, two. The faculty in 1881 consisted of the president, Rev. H. R. Revels, D. D., who was professor of mental and moral philosophy; professors of mathematics and natural philosophy, and ancient and modern languages and literature; tutors of English branches and penmanship; and the foreman of the farm. The students numbered 185. Only 15 of these were in the collegiate department. Of those preparing for college 50 had a classical course in view; 90, a scientific. Tuition is free, and expenses are made as low as possible. Further figures are presented in the table in Appendix B, which will show the financial condition and other facts relative to the college.

MISSOURI.

UNIVERSITY OF THE STATE OF MISSOURI.

The University of the State of Missouri is located at Columbia, in a beautiful and picturesque limestone region, on an elevated rolling table land lying back from the north side of the Missouri River. It was chartered by the legislature of 1838–'39, and went into full operation on the 4th of July, 1840. Only a collegiate department was established at that time, though a medical school at Saint Louis was associated with the university. Agricultural instruction was commenced in 1859, in connection with the teaching of chemistry. No new departments were added until after the close of the war. During that period it had a precarious existence. The constitution adopted by the State in 1865 required the general assembly to "establish and maintain a State university, with departments for instruction in teaching, in agriculture, and in natural science, as soon as the public school fund will permit." The condition of the university at a time little later than this is stated in one of its publications as follows:

"When Dr. Read came on the ground (in 1866) with a view of determining his course of action as to accepting the position to which he had been elected, he found the university largely involved in debt; its officers paid in university warrants, inconvertible except at a large discount; the payment of the income of the endowment fund suspended during the process of the conversion of the bank stock into United States bonds, as required by the new State constitution; the university building greatly defaced and injured in consequence of its occupation by United States troops, and some of the rooms unfit for use; the roof leaky and the plastering fallen from the ceilings of many of the rooms. * * * Upon the first week of the opening of the session not a single student appeared to matriculate, there being a county fair in the neighborhood, and on the second less than forty came forward for that purpose."

The prosperity of the university dated from the subsequent year. The State then began to render aid. A normal college was opened in 1868, and other colleges have been added since. The university now has suitable buildings, all necessary apparatus, and a valuable library of about 13,000 volumes and as many pamphlets. It has been governed by a broad and liberal policy, the principles of which were stated a few years since to be as follows:

"1. To keep the university perfectly free from complications of party politics and sectarian religion.

"2. To adapt the university to the peculiar needs of Missouri by giving it that scientific cast required by our special circumstances; also, while furnishing the highest instruction in various departments for the scholar, to afford instruction to a large class who require shorter courses to prepare themselves for specific pursuits.

"3. To give the largest practicable liberty of choice in the selection of studies, according to the most advanced ideas of the day, a system commenced in the University of Virginia. * * *

"4. To admit women students to classes as they may desire; to keep the expenses of university education at the lowest practicable point to the student by diminishing the rate of tuition one-half and providing the means of cheap boarding.

"5. To aid and encourage our local and denominational colleges by opening the doors of the university, without money and without price, to their graduates, in order that they may avail themselves of the larger educational means afforded by the State in the university. In short, it has been a settled policy to make the university an institution for the whole of Missouri, and not for any section, party, or partisan clique."

FINANCIAL CONDITION.

The two townships received by Missouri when admitted into the Union in 1820, for the support of a university were sold at $2 an acre in 1832. The net sum realized was about $70,000. This was kept at interest, and amounted to $100,000 before the end of the decade. Then it was determined to establish a university, and a bonus of $117,500 was offered by Boone County for its location at Columbia. These funds were used for the erection of a building and other necessary expenses, and the endowment of the university. Missouri received nominally 330,000 acres of land by the grant of 1862 for agricultural colleges. Really it was somewhat less, in consequence of a provision requiring that one acre taken within the railroad belt should be counted as two. After a long struggle it was decided that the State University should have the benefit of the grant. Most of this land remains unsold. Some of it is leased. The income from rents and the interest on amounts realized from land sales has not been large. The land is increasing in value, and will eventually provide a handsome endowment. The recent reports of the property and income of the university, as made to the Bureau of Education, are as follows:

	1880.	1882.
Value of grounds, buildings, and apparatus	$150,000	.....
Amount of productive funds	227,000	$480,000
Income from productive funds	13,620	27,500
Receipts from tuition fees	11,295	.....
Receipts from State appropriations	27,000	.....

ORGANIZATION.

The organization of the Missouri University is unlike that of ordinary colleges and universities. A general plan was adopted fifteen years ago, and has been adhered to since. It was as follows:

I. To retain substantially the usual college curriculum for those who desire that course.
II. To enlarge and perfect the scientific course.
III. To establish and maintain—
  1. A college of agriculture and mechanic arts, which, in addition to instruction in agriculture, horticulture, military tactics, etc., shall embrace schools of engineering, analytical chemistry, and mining and metallurgy.
  2. A normal school.
  3. A law school.
  4. A preparatory school.
IV. To expand the university by instituting colleges of applied science or professional departments, as its means will permit or the wants of the State demand.
V. To accumulate the materials of education, as books, apparatus, cabinets, models, etc.
VI. To adjust the different departments of instruction so as to economize labor and material, and thus render the institution the most effective to the largest number, and save means for the enlargement of the university and the increase of its facilities.
VII. To exercise judicious economy in all departments, that there may be improvement in all, and the accumulation, year by year, of those educational means and appointments which belong alike to all departments and increase the general prosperity.

In pursuance of this plan the university is organized into a college, in which the subjects of instruction are arranged in academic schools of (*a*) science and (*b*) language and professional schools. The schools of (1) physics, (2) chemistry, (3) natural history, (4) mathematics and astronomy, and (5) metaphysics constitute the schools of science; those of (1) Hebrew and Semitic literature, (2) Greek, (3) Latin, (4) modern continental German, French, Spanish, and Italian, and (5) English form the schools of language. The first three schools of science are closely related to industrial education, and consequently deserve more than simple mention.

The *school of physics* is under the charge of a single professor. In it not only academic, but agricultural, normal, medical and special students are instructed. The study of the assigned text-book and the recitation are supplemented by laboratory work and by lectures. The laboratory work familiarizes the student with physical apparatus, of which the university has a fair supply, and fixes in his memory the principles and the

processes which he sees illustrated. The lectures elaborate more fully subjects of special difficulty or interest, as, for example, the steam engine.

The *school of chemistry* is under the supervision of a professor and his assistant. In it there are distinct courses of study in (1) phenomenal, (2) rational, (3) domestic, and (4) agricultural chemistry, and (5) toxicology. The course in phenomenal chemistry is elementary, and must be pursued by all the students of the university, except those in law, before they can receive a diploma or be admitted to other classes in the chemical department. The course in rational chemistry is a continuation of it. Organic and applied chemistry largely enters into this course. Domestic chemistry is taught the students in the ladies' department by lectures on the general subjects of air, water, food, and cosmetics. Agricultural chemistry is also taught by lectures treating of the structure and functions of plants, the properties of soils, the composition and value of fertilizers, and other subjects similarly related to agriculture. The instruction in toxicology is given principally to medical students by a course of lectures lasting about two months. The chemical laboratory is furnished in the most approved style, with working tables, reagents, and general apparatus.

The *school of natural history* is in the charge of two professors, and their instruction is supplemented by lectures by other members of the university faculty. The subjects of instruction include geography, botany, entomology, anatomy and physiology, zoölogy, comparative anatomy, mineralogy, paleontology, geology, and physical geography. The last subject is taught at the end of the course, as it is more readily understood after a study of the individual branches of natural history, and is a review of that whole subject. Especial attention is given to zoölogy, botany, and entomology.

The other academic schools do not contribute directly to industrial education. They furnish general culture and discipline, and their studies make up the larger part of the courses which must be pursued by undergraduates seeking a degree. These courses are four in number, namely: Course in arts, in science, in letters, and girls' course in arts. Each covers four collegiate and two preparatory years, and it is estimated that four hours a day five days in the week will be required for recitation and eight hours a day for study. The course in arts is the old-time classical course slightly modified, and leads to the degree of bachelor of arts. The course in science gives prominence to mathematics and sciences; that in literature, to Latin and the modern languages. Their degrees are respectively bachelor of science and bachelor of literature.

LADIES' DEPARTMENT.

The girls' course in arts is made up substantially of studies selected from the other academic courses, with additional work in literature, composition, and criticism, and diversified by studies peculiarly adapted to the culture of woman, such as calisthenics, music, physiology, and domestic chemistry and economy. The degree of bachelor of domestic arts is conferred upon those successfully completing it. Young ladies may choose any academic course, but this one is the most popular with them. Its establishment has tended to increase their number, which has already reached nearly a hundred. The ladies are required to wear a prescribed dress and are expected to engage in calisthenics. The opportunities for the study of music are good, and it is thought that they will be greatly increased in the immediate future.

PROFESSIONAL SCHOOLS.

There are nine professional schools connected with the Missouri University. They are the law school, attendance in 1881–'82, 38; medical school, 36; normal college, 83; commercial school, 105; school of art, 140; school of military science and tactics, 53; engineering school, 42; agricultural and mechanical college, 21; and the school of mines and metallurgy at Rolla, 82. Each has a faculty of its own, or else is in charge of a single professor, who is aided in the work of instruction by other members of the university faculty as may be necessary.

The *engineering school* has a faculty of nine members, composed of the president of the university, who is professor of the science of mind, and professors of mathematics and astronomy, civil and topographical engineering, free-hand and topographical drawing, military science and tactics, geology, chemistry, economic botany, and law. Instruction is also given by visiting lecturers on engineering. Fees are $40 a year. Forty-two students were in attendance in 1881–'82. In their professional preparation they are instructed in the following subjects, among others: The location and construction of roads, railroads, canals, and water-works; the surveys and improvements of coasts, harbors, rivers, and lakes; the determination of astronomical and geographical coördinates on land and at sea; the design and construction of roofs and trusses, girders, and suspension bridges; drawing and constructing the various kinds of arches; the design, ap-

plication, and construction of wind and hydraulic motors, air and steam engines; blowpipe analyses of minerals, and economic geology, mineralogy, chemistry (elementary and applied); the art of war; the preparation of the various kinds of projections and drawings used by the military, topographical, civil, and mine engineer; the selection, tests, and applications of materials used in constructions; and papers and essays on professional subjects. In order that the student may pursue those branches which are preparatory to special departments of engineering, courses of study covering the last two years of a six years' course are offered in (1) civil engineering, (2) topographical engineering, (3) surveying and astronomy, and (4) military engineering. The college course in science prepares the student for the professional study of any of these branches. Instruction is given by text books, lectures, and field and observatory practice.

Agricultural and Mechanical College.

After a discussion, continuing seven years, the Agricultural and Mechanical College of Missouri was located at Columbia in immediate connection with the university. The county of Boone and the city of Columbia gave land costing $60,000 and $30,000 in bonds for the sake of having the college within their limits. Three-fourths of the income of the land grant belongs to the college, and the State cares for those wants which the income from fees and productive property cannot supply, as it does for the university. The attendance of students has not been uniformly large. In 1873 there were 138; in 1881–'82, 21. A few students have taken the degree of bachelor of agriculture; a considerably larger number have received certificates of proficiency in horticulture. The fees are the same as the ordinary university fees, namely, an annual entrance fee of $10, and $10 a year for incidentals and use of library.

The course of study has been made strictly professional and reduced to two years, the first, horticultural; the second, agricultural. Those completing the first year are entitled to the certificate in horticulture. The full course leads to the degree of bachelor of agriculture. The requirements for admission are very slight. The studies of the first year are: *First semester*, propagation, pruning, training, soils, fertilizers, tillage, and drainage; pomology, nursery business, forestry, and meteorology; physics and mechanics; and nursery work at the discretion of the professors. *Second semester*, gardens and gardening; entomology; orchards, vineyards, fruit gardens, ornamental trees, and landscape gardening; botany; work in gardens and vineyards. The studies of the second year are: *First semester*, zoölogy and veterinary science, farm crops, surveying, agricultural chemistry, mineralogy, mechanical drawing, and field work or feeding and care of stock: *Second semester*, farm buildings, machinery, fences, and water supply; domestic animals, geology, roads and bridges, and farm law, with out-door work.

Six prizes are offered, as follows: To the junior class (1) for best essay on pruning, Loudon's Encyclopedia of Gardening; (2) for best specimens of propagation, including apples, pears, grapes, gooseberries, and strawberries, 20 plants each, $10; and (3) for best show of garden vegetables, including tomatoes, cabbages, onions, pease, and beets, 20 plants each, $10. To the senior class (1) for best corn culture, ¼ acre, $10; (2) for best reaping, binding, and stocking, ¼ acre, $10; and (3) for best specimen of plowing, ¼ acre, $10. The college furnishes land and materials; the contestant must do all the work.

The college farm contains some 640 acres, has a variety of soils, and is well watered. It offers opportunities for student labor, practical work, and agricultural experiment. The value of different varieties of wheat, corn, and potatoes has been tested. Gardens, vineyards, and orchards have been planted, and will be closely observed. A commercial nursery is a special source of profit. A plantation of forest trees has been commenced.

School of Mines and Metallurgy.

The School of Mines and Metallurgy is located at Rolla, Phelps County, in the midst of an extensive and rapidly developing iron section and near districts abounding in lead and zinc deposits. The institution was established in February, 1870, and opened in November, 1871. Its design is to unite with the agricultural college in carrying out the purposes of the national grant in aid of industrial education. This object has been kept in view in arranging the studies of the school, in selecting its apparatus, and in organizing its faculty.

The school has a one-fourth interest in the agricultural college lands. It still receives its chief support from State appropriations, that for 1881 being $7,500. It also received in that year $800 from students' fees and $3,300 interest on its productive funds, which amount to $55,000. Its buildings, grounds, and apparatus are valued at $46,660.

The faculty of the school is composed of professors of mathematics, civil and mine engineering and graphics, analytical chemistry and metallurgy, physics and natural history, and languages. The last is principal of the preparatory department, and has an

assistant. The number of students reported for 1881 was 82. Of these 25 were preparatory students, 45 in partial courses and 12 in regular courses. The annual fees are $20.

The graduates previous to 1882 numbered 24; the licentiates, 25. They are engaged largely in teaching, studying, and professional work of kinds for which the school furnishes preparation.

Great freedom is allowed students in the choice of studies, and five courses of study are arranged in addition to the preparatory course of one year. There is a teachers' course, two years in length, which includes the usual English studies of a high school and normal instruction. Those completing it are assured of a first-class teacher's certificate, good for two years, from the State superintendent of public schools. A girls' course in arts extends over four years. The professional courses are three years in length, and lead to the degrees of mining engineer, civil engineer, and bachelor of philosophy, respectively. Analytical chemistry, mineralogy, geology, metallurgy, pure and applied mathematics, artistic and mechanical drawing, and civil and mine engineering form the main branches of study.

The school is well furnished with apparatus, instruments, and other appliances for practical instruction and demonstration. It has a full supply of excellent surveying and engineering instruments, physical apparatus, embodying the newest forms for illustration and research, together with diagrams and models for the illustration of metallurgy and for engineering, topographical and ornamental drawing. The geological, mineralogical, and technical collections are all rapidly increasing, and are already rich in specimens and products illustrative of the mineral industries of Missouri. The laboratories for analysis and assaying have been increased in working capacity, and are amply furnished with apparatus and reagents necessary for practical instruction and for any line of chemical and metallurgical research. The library of 2,750 books and pamphlets has been selected with special reference to supplementing the labors of the class and lecture room, and consists, therefore, largely of standard reference works on the physical sciences, mathematics, and technology. A good selection of technical periodicals is supplied to the reading room. Earnest efforts are constantly made to increase the efficiency of all the means of practice and illustration.

The rooms of the school building are comfortably furnished, well lighted, and well ventilated. The first floor is occupied by the analytical laboratory, the chemical lecture room, and the room of the professor of geology. On the second floor are the public hall, the office, library, reading and engineering rooms; and in the third story are the rooms of the professors of mathematics and English and a large drawing room, with ample accommodations for upwards of eighty students. The basement contains the assay furnaces and other appliances for metallurgical work.

A recent report of the School of Mines and Metallurgy gives the following quotations concerning the organization, equipment, and effective character of the school, taken from an official report of the visit and examination of the legislative committee on mines and mining:

"We do not intend to eulogize this institution with high-sounding phrases, nor do we mean to underrate the difficulty that each undertaking meets with during its incipient stage; but with pride we acknowledge the unanimous opinion of your committee that this school is highly worthy of the people of the great State of Missouri and in full coincidence with the intent which led to its creation. We may look forward with well-founded hopes that by the practical working of this school our dormant mineral wealth will meet the attention of the entire civilized world.

"The force of professors employed to teach the various branches of learning has been selected with more than usual care, and their ability and devotedness justify the highest expectations.

"Analytical chemistry, mineralogy, geology, metallurgy, mathematics (pure and applied), drawing (artistic and mechanical), civil and mine engineering, military tactics, etc., form the main branches of study in this institution.

"The apparatus, mathematical and philosophical instruments, are all of the latest and most approved kind, and their selection shows excellent tact; the laboratory is in good working order, and the library, consisting mainly of technical works, contains a large number of rare volumes.

"The morals of the students are vigilantly looked after, and the remarkable progress made by them is not only noteworthy, but also a source of gratification to your committee.

"The maps of surveys and mines, the drawings of furnaces and reduction works, prepared by the more advanced students, display art and mastery on the subject of their study and labor.

"A remarkable feature of the school consists in combining theory with practice."

NEBRASKA.

THE UNIVERSITY OF NEBRASKA.

[Statement by Prof. S. R. Thompson.]

The University of Nebraska exists by virtue of an enactment made by its first legislature soon after it became a State. This act, passed in 1869, provided for the organization of six colleges, as follows: 1. A college of literature, science, and the arts. 2. A college of agriculture. 3. A college of law. 4. A college of medicine. 5. A college of practical science, mechanics, and civil engineering. 6. A college of fine arts. Only the two first named could be opened without consent of the legislature.

The regents appointed under this act organized, elected a chancellor and faculty, and opened the college of literature, science, and art in September, 1871. During this year a professor of agriculture was chosen and arrangements made to open the agricultural college in the autumn of 1872. The plan was to have students in the agricultural college take their scientific and literary studies in the college of literature and science, so that only special and technical instruction need be provided in the other.

In 1874 an improved farm of 320 acres was procured and provided with a fair outfit of stock, teams, and tools. In 1875 a dormitory to accommodate about 20 students was erected, and henceforward all students in agriculture were to reside on the college farm. In 1877 the law was amended so as to consolidate the second and fifth colleges of the original scheme into one to be called "The Industrial College, embracing agriculture, practical science, civil engineering, and mechanic arts." In 1881 a professor of horticulture and a tutor in civil engineering were appointed; these, with the professor of agriculture, who is dean of the industrial college and superintendent of the farm, now constitute the teaching force of this department.

The classes in both colleges use the same building for recitation and general purposes. Students in the agricultural course reside on the farm and work an average time of two hours a day. Part of this labor is compensated and part not. All other students find boarding in or near the city as they prefer.

The course of study in the department of civil engineering is not materially different from that of other schools of like character. The studies of the first four years are substantially the same as those of the scientific course, most of the special and technical studies being assigned to the junior and senior years.

The course in agriculture is of the same length and difficulty as other courses in the university, viz: four years, with two of preparatory work, which may be taken in the university if desired. The following is a list of the studies which are taught to students in the agricultural college only: Practical agriculture, book-keeping, horticulture, laying out and improving farms, farm implements and machinery, entomology, anatomy and physiology of domestic animals, stock raising, meteorology, rural and domestic sanitation, vegetable physiology applied to farm crops, landscape gardening, bee keeping, agricultural chemistry, cryptogamic botany, sorghum manufacture, and the history and literature of agriculture.

As regards means of illustration of subjects peculiar to the industrial college there is now provided a farm of 320 acres, all improved, with good buildings, orchards, timber plantation, a nursery, the beginning of an arboretum, a vineyard, five breeds of cattle, two of hogs, thirty stands of bees, and an agricultural reference library of 300 volumes. There is also a fair outfit of meteorological instruments for making observations on the weather. The State volunteer weather-service has its central station at the college and publishes a monthly bulletin.

A considerable amount of experimenting has been undertaken, and it is intended to enlarge that work as fast as possible.

The mechanical department has not been organized, but the legislature which meets the coming winter will be asked to provide for it.

Since its opening in 1872, in all about 60 students have attended the industrial department. Four have graduated, three in agriculture and one in engineering. Of these one is now professor of horticulture in the institution, two engaged in farming, and one is in charge of an engineering party of the Union Pacific Railroad in Wyoming. At present there are enrolled 3 seniors, 5 juniors, 3 sophomores, 4 freshmen, and 7 in the preparatory. This number, though small, is all that can be accommodated on the farm with boarding and rooms until additional buildings are erected.

Besides the special facilities for study and instruction above enumerated, students in this department have access to the university library of 4,000 volumes, to the cabinet containing some 70,000 mineralogical and geological specimens, to the herbarium with 25,000

species of plants, and to the entomological collection of 5,000 specimens. Facilities for teaching analytical chemistry and physics are good, and the engineering department has a good level, transit, and other apparatus for field work.

The number of students enrolled in all departments of the university for the year 1881–'82, according to the catalogue soon to be issued, was 284, of whom 101 were in the colleges classes and 183 in the preparatory school.

The whole number of professors and instructors now employed in the university is sixteen. The entire support of the university has hitherto depended on appropriations by the State legislature. Within two years some of the endowment lands have been sold and more leased, but the income cannot be used till authority is granted by the legislature. The funds arising from sales of educational lands are made by the constitution trust funds and cannot be granted by the legislature for any but educational purposes. No part of the school or university lands can be sold for less than $7 an acre.

The appropriation made in 1880 to the university was $28,000 per annum for two years.

NEVADA.

STATE UNIVERSITY.

[Prepared from latest reports on file in this office.]

The State University of Nevada has received from the general government, by act of Congress, the usual grant of land for university purposes, 46,080 acres, and also 90,000 acres as endowment for college of agriculture and the mechanic arts.

The agricultural land from the grant has been sold, and the fund, $90,000, is set aside for the college, not yet organized. The interest, 8 per cent., is being added to the principal.

The university is located at Elko, in the eastern part of the State. A preparatory department has been organized.

In 1880, the faculty consisted only of the principal and one professor. The pupils numbered 48, 26 of whom were girls.

Tuition is free. Board and expenses at university dormitory, about $30 per month.

The value of buildings, grounds, and apparatus is stated at $25,000. Annual income by State appropriation, $6,000.

NEW HAMPSHIRE.

COLLEGE OF AGRICULTURE AND MECHANIC ARTS, DARTMOUTH COLLEGE.

[Prepared from latest reports and catalogues on file in this office.]

HISTORY AND OBJECTS.

The New Hampshire College of Agriculture and the Mechanic Arts is an institution associated with Dartmouth College, Hanover, and has for its object, "the liberal and practical education of the industrial classes in the several pursuits and professions of life." It was founded in 1866, by the State legislature, in accordance with the provisions of the agricultural college legislation.

ENDOWMENT AND FUNDS.

The original endowment of the institution ($80,000) was derived from the proceeds of the Congressional land grant, which, on being sold, was invested in New Hampshire State bonds, the interest (6 per cent.) on which constitutes the chief source of annual income.

The scrip received, representing 150,000 acres, was sold at 53⅓ cents per acre. The endowment has been increased to $100,000. Total annual income therefrom, $6,000; State appropriations (1880) for two years, $3,000; total, $9,000.

The tuition fees are stated at $30 per school year, but, as there are 34 free scholarships and an average annual attendance only slightly more than that number, the income from this source is small.

The total valuation of the college property, farm, buildings, apparatus, &c., is given at $100,000.

STUDENTS AND DEGREES.

According to catalogue of 1881–'82, the number of students was 41, of whom 10 were seniors, 13 middlers, and 18 juniors. No women are admitted.

In 1881 the degree of bachelor of science was conferred upon 14 young men.

THE FACULTY.

The staff of the College of Agriculture and the Mechanic Arts consists of the president, professors of chemistry, natural history, mathematics, and English language and literature, instructors in elocution and drawing, with lecturers (occasional) on the history of agriculture, farming as a profession, irrigation and drainage, veterinary science, stock-breeding, theoretical and practical farming, dairying, ensilage, fruit culture, and sheep husbandry. The lectures are arranged in a course which is given each winter and are open to all.

COURSE OF STUDY.

There is but a single course of study, covering a period of three years. The studies of the first or junior year include algebra, geometry, trigonometry, Grecian, Roman, mediæval and modern history, physiology, zoölogy, botany, drawing, and bookkeeping.

The studies of the second year are mechanics, surveying, and field work; physics and chemistry, with laboratory work; rhetoric and English literature; business law. The optional studies provided for the first term of the year are theory of equations, entomology, and history of civilization.

The regular studies of the senior year are physics, blowpipe analysis, astronomy, meteorology, geology, mineralogy, mechanics, English and American literature, constitutional law, and political economy. The optional studies include assaying, general geometry, analysis of farm products, and international law.

The assignment of agricultural lectures to the different years is: *Junior year*, lectures on history of agriculture, forestry, drainage, and irrigation; *middle year*, lectures on soils, plant growth, stock feeding, stock breeding, ensilage, and fruit culture; *senior year*, dairying, diseases of animals, sheep husbandry, and general methods of farm management.

APPLIANCES, FARM TOOLS, STOCK, AND POLICY.

The library belonging to this institution contains about two thousand volumes, chiefly valuable scientific works. The students also have access to the library, the cabinets, and the observatory of Dartmouth College upon the same terms as the students of the latter.

A State museum of general and applied science has been established. The specimens accruing from the State geological survey have been devoted to this institution by the legislature. Various contributions have also been made by persons interested in this object, and others are solicited.

The chemical laboratory is commodious, well lighted, and well ventilated, and is furnished with appliances for instruction in general, analytical, and agricultural chemistry.

The college is provided with instruments for practical surveying and with apparatus for illustration. The students also have the benefit of the valuable philosophical apparatus belonging to Dartmouth College, and attend the lectures on physics and other subjects.

A valuable tract of land of 360 acres in the immediate vicinity of Culver Hall (the principal college building) was secured, and for several years it has been under cultivation as a college farm. In convenience of access and in the character of the soil it is admirably suited for the purposes of agricultural experiment.

It is the intention to keep upon the farm a full line of such agricultural implements as promise to be of practical value, and their use has reduced the manual labor employed to a minimum.

The stock consists of 50 cattle, pure (milk producing) Durhams and Ayrshires, and their grades; 40 Cotswold sheep, 3 horses, &c.

The farm policy is to pass from the conservative rule of "small areas richly tilled" to larger areas; but these are well supplied with fertilizers, by means of rich foods given to the stock, such as meal, bran, cotton seed meal, &c. Chemicals are also used in the nutrition of crops.

CROPS, EXPERIMENTS, LABOR.

The crops for 1880 consisted of 6 acres of sugar beets; one-quarter of an acre of sorghum; 3½ acres of barley; 7 acres of oats and pease; 24 acres of corn; 8 acres of clover; 4½ acres

are devoted to experiments, and the remainder of the tillage is in grass. Corn yields 60 to 70 bushels per acre; oats, 60 to 80 bushels; grass, 2 to 3 tons.

Experiments are always being carried on. They are so conducted as to be of direct use to the practical farmer as well as to the agricultural scientist.

Among the recent experiments have been those respecting root feeding, the comparative merits of different corn-meals and brans, early and late cut hay, the preparation and use of fertilizers and the value of foods.

Student labor is employed at 12½ cents per hour, instruction being at the same time afforded in the use of farm machinery and in the experiments and work of the farm.

The scientific and engineering departments of Dartmouth College, known respectively as the Chandler Scientific School and the Thayer School of Engineering, are accessible in a general way to the students of the Agricultural College, and afford facilities for the study of the mechanic art.

Mention of these schools has been made in this report among the institutions grouped as not endowed by the agricultural land grant.

NEW JERSEY.

RUTGERS SCIENTIFIC SCHOOL, NEW BRUNSWICK.

Rutgers College is one of the few institutions of its kind which were organized before the revolutionary war. Its life during that period and through many years of the present century was surrounded with peril. A few decades only have passed since its ultimate prosperity was assured. In the early part of the civil war the attention of its officers was called to the importance of introducing scientific instruction, and in 1863 a new department was organized for this purpose and named the Rutgers Scientific School. It was determined by the State legislature in 1864 that this school should receive the benefit of the national land grant of 1862. The act of the legislature directed the interest on the proceeds of the land scrip to be paid to the trustees of Rutgers College, "to be used wholly and exclusively for the maintenance of such courses of instruction as should carry out the intent of the act of Congress," *i. e.*, those relating to agriculture and the mechanic arts and adapted "to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." It required the trustees to furnish instruction free to a designated number of students from the several counties of the State; to erect additional and adequate buildings when they should become necessary, without charge to the State; and in like manner to provide a suitable tract of land, conveniently located, for an experimental farm. It also prescribed the appointment of visitors, made it their duty to visit the college at least twice a year and report to the legislature, and gave them general powers of supervision and control. Thus Rutgers Scientific School became the "State College for the benefit of Agriculture and the Mechanic Arts."

The relations which exist between the old college proper and the State college are stated in a recent account of Rutgers College, as follows:

"The two are served by the same professors; their classes, though distinct, unite in many subjects in the same recitations and are known by the same designations. The interests of the two departments, in short, are made to harmonize with and to aid each other, and the reciprocal benefits derived from this intercommunication and union can hardly be exaggerated. The young men in the literary department are allowed to pursue practical chemistry by making actual analyses in the laboratory along with the scientific students; and the latter in turn compete with the former in elocution and composition, in mental and moral philosophy, in political economy and constitutional law, and in biblical recitations. The scientific students are thus preserved from the narrowing process of a purely technical education. They do, indeed, get enough of technical training to prepare them, when a little experience has been added to their theoretical knowledge, for entrance at once upon civil engineering and analytical chemistry and into various mechanical and industrial spheres; but along with this they absorb the refining and liberalizing influences which spring from the enlarged culture alluded to above. * * * In addition to this the students of both departments join the same literary societies, and thus confer upon each other all the advantages resulting from the generous emulation and contact of minds engaged at many points on different subjects and having different objects of ambition."

The opportunities for education offered by the State college have been increased by the extension of two regular courses of study from three to four years, and by the provision of special agricultural and chemical, and post-graduate courses.

ENDOWMENT AND PROPERTY.

The direct endowment and income of the scientific school are derived from the proceeds of the national land grant. The land scrip received represented 210,000 acres and was sold for $116,000,55 cents an acre. This amount is invested in New Jersey State bonds at 6 per cent. per annum, and thus produces $6,960 a year. This sum is devoted to the payment of salaries. The amount received from tuition fees is small, as nearly all students have the benefit of the State scholarships.

The trustees of the college had expended for the school previous to 1874 $30,000 for a farm, $50,000 for buildings, and $13,000 for equipment and miscellaneous expenses.

The financial report of the college to the Bureau of Education for the year ending March 31, 1881, presents the following items:

Value of grounds, buildings, and apparatus	$400,000
Amount of productive funds	303,129
Income from productive funds	20,215
Receipts from tuition fees	3,270

FACULTY.

The faculty of the Rutgers Scientific School is composed of the president (professor of moral philosophy) and professors of geology and agriculture, rhetoric, logic, and mental philosophy, mining and metallurgy, history, political economy and constitutional law, French and German, inorganic and organic chemistry, mechanics and physics, mathematics and engineering, mathematics and graphics, mathematics and astronomy, analytical and applied chemistry, and military science and tactics, and an assistant in analytical chemistry. The college has also professors of the Latin, Greek, and English languages and literatures.

COURSES OF STUDY.

There are four years' courses of study in (1) civil engineering and mechanics and (2) chemistry and agriculture, two years' courses in (1) chemistry and (2) agriculture, and post-graduate courses.

The studies of the two full courses are the same during the first year, and are designed to furnish either a suitable introduction to the pursuit of the several courses, or a course complete in itself, suitable for those who desire to fit themselves for land surveying. During the last three years the subjects of higher mathematics, mechanics, and engineering, in the engineering course, are replaced by analytical chemistry, practice in the laboratory, and agriculture in the other course. The studies of the sophomore year are alike in the two courses, except the special professional branches. The common studies are chemistry, history, mental philosophy, descriptive geometry, shades and shadows, perspective, and the graphical solution of problems in these subjects and in solid geometry and the intersection of surfaces and solids. The special studies of the course in chemistry and agriculture for this year are qualitative and blowpipe analyses and laboratory practice; of the engineering course, railroad curves, analytical geometry, and essays in literary criticism.

The junior year in chemistry and agriculture embraces the following: German; analytical chemistry, by text book; laboratory practice and lectures; agriculture: lectures at the farm, vegetable physiology; natural philosophy; history of civilization; political economy; international law; constitutional history of United States; drawing, lettering, tinting, with ink shading, flat and graded; constructions; mineralogy.

The senior embraces organic, applied, and other departments of chemistry and chemical work; geology; principles of agriculture: its methods and products, animal physiology: care and management of domestic animals; laboratory practice and theory; moral philosophy; drawing; thesis.

The junior year in civil engineering and mechanics includes the following studies: German; natural philosophy; history of civilization; constitutional history of the United States; political economy and international law; differential and integral calculus; astronomy; drawing, lettering, tinting, with ink shading, flat and graded; construction, &c.

The senior year embraces mechanics; engineering; bridge building; railway practice; geodesy; geology; organic chemistry and chemical physics; indeterminate analysis; moral philosophy; drawing: mechanical, architectural, and engineering; thesis.

SPECIAL COURSES.

The special course in chemistry extends over two years. The first year is devoted to inorganic chemistry; qualitative, quantitative, and blowpipe analyses; chemical physics; stoichiometry; French; a thesis and a journal of travel and observation.

The work of the second year includes organic and applied chemistry; chemical physics; quantitative analysis; assaying; mineralogy and geology; German, and thesis.

The special course in agriculture requires the following studies:

During the first year, algebra; geometrical problems; inorganic chemistry; physiology and zoölogy; geometry; coloring and topographical drawing; analytical chemistry; mineralogy; bookkeeping; trigonometry; mapping; analytical chemistry; botany; farm accounts.

During the second year, surveying; projections; natural philosophy; study of domestic animals; systematic agriculture; navigation and nautical astronomy; architectural drawing; physics; geology; how crops grow; leveling and roadmaking; machine drawing; meteorology; botany; how crops feed. Composition and declamation throughout the whole course.

The hours of lectures or recitations are four each day, besides work in the chemical laboratory.

Post-graduate courses may be arranged in chemistry; geology and natural history; geology, metallurgy and engineering; agriculture; mathematics (geodesy, pure mathematics, astronomy, theoretical and applied, and the use of physical apparatus); modern languages; and political and social science. Students completing a full course of two years, in any two of these lines of study, are entitled to the degree of doctor of philosophy. Those completing either of the four years' courses receive the degree of bachelor of science. The practice of giving the degree of master of science as a matter of course to all graduates of three years' standing has been discontinued.

Partial students may enter at any time and elect, under the advice and direction of the faculty, such studies as they are qualified to pursue with classes already formed. Such students are required to have their time fully occupied and receive certificates at the close of their study showing the amount and kind of work performed.

STUDENTS.

The number of students in attendance at Rutgers College in 1881 was 143. Of these 6 were post-graduates, 10 special students, 87 members of the classical department, and 40 in the scientific department, 10 being seniors, 8 juniors, 4 sophomores, and 18 freshmen. Nearly all the counties of the State are represented in this scientific school. Forty students are admitted free of expense for tuition on the recommendation of the superintendent of schools, each county having the right to nominate a number of candidates proportional to its representation in the legislature.

In filling these State scholarships the trustees have, from the first, interpreted the law liberally, and adopted the policy of allowing any vacant scholarship to be filled temporarily by applicants from another county, provided the superintendent of the county entitled to the scholarship gives his consent. Tuition is habitually remitted to students who are unable to pay that in addition to the other expenses of procuring an education.

GRADUATES.

The occupations of 158 persons who have been educated in the scientific school are known to be as follows: Engineering, 47; business, 32; manufacturing, 20; farming, 19; teaching, 13; medicine, 12; law, 10; architecture, 5.

APPLIANCES AND COLLECTIONS.

The students in the State college have the freest access to apparatus, appliances, library, and all other aids and agencies at the disposal of Rutgers College. These include a large variety of apparatus to illustrate the domain of physics, and ample laboratory and other appliances for the courses in chemistry; a large and well-lighted drawing room; a fine observatory, the gift of Daniel S. Schanck, a two-story building, with revolving dome, containing a large equatorial telescope, a fine meridian circle, sidereal clock, and other appliances; a museum, located in Geological Hall, and containing collections in mineralogy, metallurgy, paleontology, conchology, and geology.

There are special cabinets of minerals, iron ores, and products, birds, fossils, and existing animals.

The general library, containing 10,500 volumes and 4,500 pamphlets, is open to students. There are also special collections numbering 4,300 volumes.

THE COLLEGE FARM.

The trustees of Rutgers purchased for the State College of Agriculture and Mechanic Arts 97 acres of land for a college farm, at an original cost for the land of $16,712.60. Up to

1873 the amount expended on this for improvements and expenses was $43,846.06. Up to the same date $23,386.61 were received from sales.

The land was in a wet and unprofitable condition. It has been thoroughly drained with seven miles of under-drains. The former swamps are now the most productive fields. The plans of working have been in the highest degree experimental and the results have been in the best sense of value to the agriculturist.

The farm is well equipped with buildings, stock, and tools, and the work done in the way of technics—theoretical and practical—is of sterling character.

The State legislature established an agricultural experiment station in 1880 and placed it mainly under the control of the board of visitors of the State College. "It has only just begun its work; but it is receiving the hearty coöperation and support of the farmers of the State, and is sending out to them bulletins containing the results of analyses and investigations on fertilizers, cattle foods, fodders, milk, &c., thus stimulating them to study their own calling and to find profit in it. The farm of the Agricultural College affords the opportunity for making proper experiments, and the rooms of the Scientific School and of Rutgers College furnish the places for the necessary chemical laboratories and experiments." So that the experiment station may be fairly considered a part of the Scientific School, and the 3,500 farmers who regularly receive its investigations and results are its students. The Scientific School teaches the "branches of learning related to agriculture and the mechanic arts," and the experiment station applies that learning to the practical operations of the farm.

NEW YORK.

THE CORNELL UNIVERSITY, NEW YORK STATE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS.

[Compiled from various official sources.]

HISTORY AND OBJECTS.

The establishment of the Cornell University is due to the combined bounty of the general government and of Ezra Cornell.

Under the act of July 2, 1862, the State of New York received for the benefit of instruction in agriculture and the mechanic arts, scrip representing about 990,000 acres of land. Determining to concentrate the fund, it was first offered to the People's College on certain conditions. Failure having been made in the observance of these conditions, in 1865 the State transferred the scrip to the Cornell University on granting the institution a charter, provided the university should admit one student from each assembly district without the payment of tuition and that Mr. Cornell should give half a million dollars as an endowment fund. This he did, adding two hundred acres of valuable farming lands contiguous to Ithaca then, and making the university from its organization in 1868 the object of most generous benefactions and watchful solicitude as long as he lived. Besides gifts of cabinets, libraries, &c., amounting to several hundred thousand dollars, Mr. Cornell bought from the State the entire land scrip to which the university was entitled at the price for which a single acre could be obtained, viz, 60 cents, agreeing to locate the scrip and sell the land, and, after deducting expenses, turn over the balance to the university. Under this arrangement the land was carefully selected and a considerable portion of it has been sold at $5 an acre.

"I would found an institution" (said Mr. Cornell) "where any person may find instruction in any study," and the charter of the university is conceived in the same broad spirit. Providing that a majority of the governing body shall never be of any one religious denomination or of no religious denomination, the charter granted by the State left the trustees at liberty to provide any instruction they might see fit in addition to that contemplated by the act of Congress establishing the colleges of agriculture and the mechanic arts. Women are admitted to all courses on the same terms as men, except that they must be one year older. They are not required to drill or to study military tactics.

ENDOWMENT.

The following information has been taken from the report of the treasurer of the university for the year ending June 1, 1881:

PRODUCTIVE FUNDS.

Cornell endowment fund	$628,596 61
Land scrip fund	473,412 87
Sage College endowment	100,000 00
Dean Sage sermon fund	30,000 00
Sibley endowment	30,000 00
Woodford medal fund*	1,500 00
Horace K. White prize fund*	500 00
Total amount of productive funds	1,264,009 48

OTHER PROPERTY.

Real estate, exclusive of western lands	$689,465 48
Equipment of departments of university	253,509 42
	942,974 90

WESTERN LANDS.

Number of acres of Congressional land grant remaining unsold June 1, 1881:

Pine land	271,952.23
Farm land	37,863.53
Land from which pine timber has been sold	27,500.00
	337,315.76

During the year ending June 1, 1881, land and timber were sold to the amount of $153,278, the average price of land being nearly $7 an acre.

The income from the various funds reached $105,435.26; from tuition it was $14,750, including rents, &c.; the total income was $128,182.95. The disbursements, including $84,609.94 for salaries, amounted to $118,987.03.

FACULTY.

The number and classification of professors and instructors given in the Register, printed in 1882, were as follows: Whole number in the faculty, 48:28 resident professors, 16 assistant professors, and 4 non-resident professors. In addition to 5 instructors and lecturers not included above, there were also various university officers employed as curators, assistant librarians, &c. There were 7 teachers employed in agriculture and its related sciences, 2 in architecture, 3 in chemistry, 3 in ancient languages and 7 in modern, 5 in history and political science, 4 in mathematics, 3 in civil engineering, 6 in mechanics and physics, 1 in philosophy and 1 in military science, 1 in physiology, and 2 in palæontology and geology.

STUDENTS.

The number of students present in 1882 was 384, 22 of them being graduate students. The attendance is considerably less than it was during the earlier years of the university—a result in part, probably, of the gradual but material elevation of the standard of admission that has been effected, and in part of the increase in the rate of tuition, which is now $75 a year.

Applicants for admission to the university (who must be at least 16 if boys and 17 if girls) are examined in English grammar; political and physical geography; physiology; arithmetic; algebra, through quadratic equations and including radicals and the theory of exponents; and plane geometry.

Holders of certificates or diplomas issued by the regents of the university or the State superintendent, or of diplomas of the State normal schools or academies and high schools whose requirements for graduation have been approved by the faculty, may waive the examination except as to algebra.

For admission to the various courses of science, literature, arts, &c., further examinations are required in French, German, Latin, Greek, mathematics, &c.

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*Funds remaining in the hands of donors, interest regularly paid.

Energetic young men desirous of defraying the expenses of their education by means of manual labor are given work in the printing office, on the farm, and about the buildings, for which they are paid at current rates; but after a somewhat extended trial of the system, the university authorities have reached the conclusion that the physical and mental stamina of few young men is such that they can safely pursue a course of study to advantage while providing entirely for their own support, and they therefore encourage applicants to come not wholly unprovided for.

SCHOLARSHIPS.

In accordance with the provisions of the act of incorporation 1 free student from each of the 128 assembly districts is admitted. The certificate of scholarship is granted after a successful competitive examination, but the usual entrance examination is not waived in the case of successful competitors.

GRADUATES.

The following table shows the number of graduates and the degrees taken for each year since the organization of the university in 1869 to 1881 inclusive:

Degrees.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	
A. B.	8	8	7	4	17	4	8	8	5	9	7	12	18	115
A. M.	.....	.....	.....	.....	1	.....	.....	4	2	1	.....	.....	.....	8
Agr. B.	.....	.....	.....	.....	2	2	1	1	2	1	.....	3	8	20
Arch. B.	.....	.....	.....	.....	1	6	4	6	7	2	4	2	.....	32
B. C. E.	.....	.....	7	16	18	15	8	12	15	14	10	7	9	131
B. M. E.	.....	.....	.....	.....	3	1	5	6	7	12	5	3	3	45
B. S.	.....	8	16	38	45	30	21	26	24	24	33	40	35	340
B. V. M.	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
B. V. S.	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1	.....	.....	2
C. E.	.....	1	.....	.....	1	4	.....	2	2	2	2	.....	2	16
Lit. B.	.....	.....	.....	.....	3	4	.....	1	2	3	7	5	5	30
M. S.	.....	.....	.....	1	.....	3	3	4	3	.....	1	.....	1	16
Ph. B.	.....	7	9	9	6	3	5	3	8	2	.....	4	4	60
Ph. D.	.....	.....	.....	1	1	1	.....	.....	1	.....	1	.....	.....	5
	8	24	40	70	98	73	55	73	78	70	71	76	85	821

No information as to advanced degrees conferred in 1880 has been available.

No record is kept of the occupations of those who have graduated, but the Ten-Year Book of the Cornell University, first published in 1878, is expected to give all needful information about graduates.

SPECIAL COURSES OF STUDY—AGRICULTURE.

I. APPLIED AGRICULTURE.

In applied agriculture five hours weekly during the fourth year are devoted to technical instruction in all its leading and most of its minor branches. The student is also required to spend three hours a day, two days in each week, in field practice, and in the handling and feeding of domestic animals.

The instruction by lectures begins with the fourth year and continues through three terms.

FIRST TERM.—Wheat: Culture, varieties, preparation of the soil, seeding, injurious insects, harvesting, threshing, marketing. Swine: The history of breeds, feeding, general management, piggeries. Farm buildings: Location, plans, material, construction, repairs and preservation, contracts, liabilities of contractors. Fields: Shape and size. Fences and gates: Construction, number, kind, repairs, durability of woods used. Farm and public roads, bridges, and culverts: Location, construction, repairs. Farms: Selection and purchase with regard to remoteness or nearness to markets, agricultural capabilities, roads, improvements, schools, and society. Titles, deeds, judgments, and mortgages. Farm-yard manures: Composition, manufacture, preservation, application. Commercial fertilizers: Composition, application, utility.

SECOND TERM.—Farm accounts. Principles of stock breeding: Law of similarity, of variation as caused by food, habit, and climate, atavism, relative influence of male and female, prepotency, sex, in-and-in breeding, crossing and out-crossing, grading up or

breeding in hue. Races and breeds: Pedigrees, leading breeds of neat animals treated as to history, markings, characteristics, and adaptation to uses, soil, climate, and locality. Breeding, feeding, and management of cattle. Butter, cheese, and milk dairies, and beef production. Sheep husbandry treated in detail same as cattle.

THIRD TERM.—The horse: Breeds and breeding, education, care, driving, stables. Farm drainage: Mapping of drains, material, construction, utility. Plows and plowing. Farm implements and machinery: Use, care, and repairs. Corn, oat, barley, and flax culture. Grasses and forage plants. Weeds and their eradication. Business customs, rights, and privileges. Notes, contracts, and obligations. Employment and direction of laborers.

II.—AGRICULTURAL CHEMISTRY.

The study of agricultural chemistry comprises analytical practice in the laboratory, and 75 lectures, embracing the following subjects:

The general principles of chemical science, accompanied by introductory laboratory practice; the chemistry of the elements and their compounds that constitute soils, plants, and animals; agricultural chemical investigators and their methods and means of working, and the literature of agricultural chemistry; the chemistry of vegetable life, and the production of vegetable substance in general; the physical and chemical properties and agricultural resources of the soil; tillage, drainage, &c., and amendments and manures; the composition of crops and other materials used for fodder; animal chemistry and nutrition; fermentation and putrefaction; milk and its manufactured products and residues; food, water, and air in their relations to human and animal life; the chemical analysis of fodder and food; farm crops and their manufactured products and residues.

The analysis of agricultural materials and products is treated in a course of chemical practice.

III.—ECONOMIC ENTOMOLOGY.

The course of twenty lectures presents the characteristics of the orders of insects, the more important families, and the species which are injurious, beneficial, or otherwise especially interesting. The lectures are illustrated by specimens of the stages and works of insects, and due prominence is given to the practical treatment of forms having an economic importance.

In the laboratory and field practice, students are instructed in all kinds of practical entomological work, involving drawings and notes of observations, with methods of collecting, breeding, destroying, preserving, arranging, &c.

IV.—HORTICULTURE.

The instruction comprises two courses of lectures during the first term, supplemented by experimental or practical work.

In the *third year* there is a course of lectures on arboriculture and landscape gardening; in the *fourth*, one on the principles of horticulture.

Additional time is given to experimental work in the garden or conservatories. The instruction in botany, both in the laboratory and in the several courses of lectures, is intended to afford a scientific basis for the special instruction given in horticulture.

V.—VETERINARY SCIENCE.

The regular course for students in agriculture, natural history, &c., embraces five lectures a week during an entire academic year; laboratory work on the bones, plastic models, pathological preparations, and parasites of domestic animals; clinical instruction on cases occurring in practice.

FIRST TERM.—Lectures on the anatomy and physiology of the animals of the farm. Attention is given to the principles of hygiene as affected by genus, breed, climate, soil, exposure, buildings, ventilation, drainage, food, and water; to the varying anatomical peculiarities which imply special aptitude for particular uses; to the data for determining age; to the principles of breeding, of shoeing, &c.

SECOND TERM.—Lectures on general comparative pathology; on specific fevers and other contagious diseases; on the parasites and parasitic diseases of domestic animals; and on constitutional diseases. An important feature in this course is the subject of veterinary sanitary science and police, embracing as it does the prevention of animal plagues by legislative and individual action, the improvement of unhealthy localities, and the destruction of animal poisons and parasites which are intercommunicable between man and the domestic animals.

THIRD TERM.—Lectures on the local diseases of the various systems of organs in the different animals and on veterinary surgery.

Opportunities are afforded to students who desire it to pursue the study of veterinary medicine and surgery further than is provided for in the regular courses of study.

THE COURSES IN AGRICULTURE.

I.—A FOUR YEARS' COURSE.

(Leading to the degree of bachelor of agriculture.)

First year.

FIRST TERM.—French *or* German, 5; rhetoric, 2; geometry and conic sections, 5; free-hand drawing, 3; hygiene, 6 lectures.

SECOND TERM.—French *or* German, 5; rhetoric, 2; algebra, 5; free-hand drawing, 3.

THIRD TERM.—French *or* German, 5; rhetoric, 2; trigonometry, 5; general chemistry and laboratory work, lectures, 3.

Second year.

FIRST TERM.—French *or* German, 3; agricultural chemistry, 5; zoölogy, lectures and laboratory work (vertebrates), 3; anatomy, laboratory work, 2. Elective, 3.

SECOND TERM.—French *or* German, 3; agricultural chemistry, lectures, 4; chemistry, qualitative analysis, 5; anatomy, laboratory work, 2, Elective, 2.

THIRD TERM.—French *or* German, 3; land surveying, 4; botany, lectures, 3, field work, 2; entomology, lectures, 2, laboratory work, 2.

Third year.

FIRST TERM.—Experimental mechanics and heat, 3; compositæ and gramineæ, 2; arboriculture and landscape gardening, 2; entomology, 3; veterinary anatomy and physiology, 5.

SECOND TERM.—Electricity and magnetism, 3; chemistry, quantitative analysis, 4; vegetable physiology, 3; vegetable histology, 2; veterinary pathology, sanitary science and parasites, 5.

THIRD TERM.—Acoustics and optics, 3; chemistry, quantitative analysis, 9; veterinary medicine and surgery, 5.

Fourth year.

FIRST TERM.—Agriculture, lectures, 5; field-work, 3; botany (fungi), 4; horticulture, lectures, 2; geology, 3.

SECOND TERM.—Agriculture, lectures, 5; field-work, 2; systematic and applied botany, 3. Elective, 5.

THIRD TERM.—Agriculture, lectures, 3, field-work, 3; building materials and construction, 2; American law, 5.

II.—A THREE YEARS' COURSE.

(Not leading to a degree.)

First year.

FIRST TERM.—Geometry and conic sections, 5; free-hand drawing, 3; agricultural, chemistry, lectures, 5, laboratory work, 3.

SECOND TERM.—Algebra, 5; agricultural chemistry, lectures, 4, laboratory work, 6.

THIRD TERM.—Trigonometry, 5; botany, lectures, 3, field-work, 2; entomology, lectures, 2, laboratory work, 2.

Second year.

FIRST TERM.—Experimental mechanics and heat, 3; compositæ and gramineæ, 2; arboriculture and landscape gardening, 2; geology, 3; veterinary anatomy and physiology, 5.

SECOND TERM.—Electricity and magnetism, 3; chemistry, laboratory work, 4; vegetable physiology, 3; vegetable histology, 2; veterinary pathology, sanitary science, and parasites, 5.

THIRD TERM.—Acoustics and optics, 3; land surveying, 4; chemistry, laboratory work, 4; veterinary medicine and surgery, 5.

Third year.

The same as the fourth year of the four years' course.

MECHANIC ARTS.

Each student in this department is required to devote two hours a day to work in the shop; but such students as have, before entering, acquired sufficient practical knowledge

are admitted to advanced standing. Attendance is required upon ten lectures or recitations a week, or their equivalent, in addition to two hours daily drawing, two hours daily shop-work, and the passing of the examinations at the close of each term.

THE COURSE IN MECHANIC ARTS.

(Leading to the degree of bachelor of mechanical engineering.)

First year.

FIRST TERM.—German, 5; geometry and conic sections, 5; freehand drawing, 3; shop work, 3.
SECOND TERM.—German, 5; algebra, 5; freehand drawing, 3; shop work, 3.
THIRD TERM.—German, 5; trigonometry, 5; geometrical drawing, 3; shop work, 3.

Second year.

FIRST TERM.—German, 3; rhetoric, 2; analytical geometry, 5; experimental mechanics and heat, 3; shop work, 3.
SECOND TERM.—German, 3; rhetoric, 2; calculus, 5; electricity and magnetism, 3; shop work, 3.
THIRD TERM.—Calculus, 5; descriptive geometry, text and drawing, 4; mechanical drawing, 2; building materials, 3; shop work, 3.

Third year.

FIRST TERM.—Calculus and analytical geometry, 5; descriptive geometry, text and drawing, 6; mechanism, 3; shop work, 3.
SECOND TERM.—Mechanics of engineering, 5; mechanism, 3; physics, laboratory work, 3; chemistry, 3; shop work, 3.
THIRD TERM.—Mechanics of engineering, 5; mechanical drawing, with shades, tinting, and perspective, 3; physics, laboratory work, 3; chemistry, 3; shop work, 3.

Fourth year.

FIRST TERM.—Mechanics of engineering, 5; mechanical and working drawings, 3; physics, laboratory work, 3; steam engine, 3; shop work, 3.
SECOND TERM.—Mechanical drawing, 4; steam engine, 3; metallurgy, 2; experimental work with indicators, governors, pumps, and injectors, 3; shop work, 3.
THIRD TERM.—Graphical statics, 3; field practice and the use of instruments, 3; industrial chemistry, 3; technical reading and preparation of thesis, 3; shop work, 3.

Graduate course.

FIRST TERM.—Machines for regulating, counting, &c., 3; mechanical *or* physical experiments, *or* chemistry, 3; riparian laws, contracts, Patent-Office laws, &c., 2. Elective, 7.
SECOND TERM.—Machines for change of form, 3; mechanical *or* physical experiments, *or* chemistry, 3; technical reading, 2. Elective, 7.
THIRD TERM.—Locomotive machines, hoists, cranes, &c., 3; mechanical *or* physical experiments, *or* chemistry, 3; shop systems and accounts, 2. Elective, 7.

The elective studies are hydraulics, assaying, mineralogy and blowpipe analysis, chemical laboratory practice, physics (acoustics and optics), motors other than steam, architecture, civil engineering, shop work, mathematics, botany, French, rhetoric, history, literature.

MILITARY SCIENCE.

The practical military exercises include:
Infantry tactics.—To comprise the schools of the soldier, company, and battalion; with skirmishing, the forms of parade, and the duties of guards.
Artillery practice.—To comprise at least the school of the piece and section for the field guns, with such further artillery instruction as may be found practicable.
Special exercises.—To comprise recitations at such times as may be prescribed.
The advanced course of instruction in military science is optional, and is open to all

undergraduates and to such special students as have sufficient scientific and practical preparation.

It requires an attendance upon a class exercise or lecture of one hour on three days of the week during one year. The subjects are:

Military engineering.—To comprise the principles of military topography; the effect of projectiles; the principles of fortification, with their application to field works; military mining; the attack and defense of works; and the construction of military roads and bridges.

The art of war.—To comprise the history and principles of special tactics; the organization of armies, with some account of the administrative arrangements of our own army; strategy; grand tactics; and accessory operations of war.

Military law.—To comprise the origin, principles, and limitations of military law; the nature and force of the articles of war and the general regulations for the army; a summary of the rules of evidence; the constitution, jurisdiction, and procedure of courts-martial, courts of inquiry, military commissions, and military boards.

ARCHITECTURE.

The course in architecture is so arranged as to give the student instruction in all subjects which he should understand in order to enter upon the practice of the art.

The instruction is given by means of lectures and practical exercises. Its object is not merely to develop the artistic powers of the student, but to lay that foundation of knowledge without which there can be no true art. Drawing is taught during the first two years, and afterwards thoroughly used and applied in mechanics, stereotomy, and designing.

Architectural mechanics occupies a part of each term for one year. The lectures are each supplemented by at least two hours of work on problems. In developing the subjects and in solving problems analytical methods are used, but for practical use special attention is paid to the application of graphical statics.

The study of the history of architecture and the development of the various styles runs through five terms. The lectures are illustrated by photographs, engravings, drawings, casts, and models.

Proper attention is paid to acoustics, ventilation, heating, decoration, contracts, and specifications. The whole ground of education in architecture, practical, scientific, historical, and æsthetic, is covered as completely as is practicable in a four years' course.

THE COURSE IN ARCHITECTURE.

(Leading to the degree of bachelor of architecture.)

First year.

FIRST TERM.—French *or* German, 5; rhetoric, 2; geometry and conic sections, 5; freehand drawing, 3; linear drawing, 1; hygiene, six lectures.

SECOND TERM.—French *or* German, 5; rhetoric, 2; algebra, 5; freehand drawing, 3; projection and tinting, 1.

THIRD TERM.—French *or* German, 5; trigonometry, 5; descriptive geometry, text and drawing, 4; botany, 3.

Second year.

FIRST TERM.—French *or* German, 3; composition and elocution, 1; analytical geometry, 5; descriptive geometry, text and drawing, 6; experimental mechanics and heat, 3.

SECOND TERM.—French *or* German, 3; composition and elocution, 1; calculus, 5; drawing, 3; electricity and magnetism, 3; chemistry, lectures, 3.

THIRD TERM.—French *or* German, 3; composition and elocution, 1; drawing, 3; acoustics and optics, 3; chemistry, lectures, 3; building materials and construction, 3.

Third year.

FIRST TERM.—Mechanics, strength of materials, 3; shades, shadows, and perspective, 3; drawing, 3; Egyptian, Greek, and Roman architecture, 3; designing, 4.

SECOND TERM.—Mechanics, trusses, 3; Byzantine and Romanesque architecture, 5; designing, 3; construction, 2; lithology and determinative mineralogy, 2.

THIRD TERM.—Mechanics, arches, 3; freehand drawing, 3; Gothic architecture, 5; designing, 3; construction 2.

Fourth year.

FIRST TERM.—Renaissance architecture, 3; decoration, 3; designing, 6; stereotomy, 3.

SECOND TERM.—Modern architecture, 3; designing, 4; stereotomy, applied to stone-cutting, 5; economic geology, 3.

THIRD TERM.—Decoration, acoustics, ventilation, warming, professional practice, measuring, contracts, specifications, &c., 5; designing, 7.

CIVIL ENGINEERING.

The instruction is given by means of lectures and recitations, with drawing and field and laboratory practice. The field work embraces the usual operations and the more recent methods of land, railroad, and subterranean surveying, together with hydrography and geodetic practice; and since 1874 the department of civil engineering has been engaged in the surveys of the hydrographic basin of Central New York as a contribution to the geodetic surveys of the United States Government.

Laboratory practice is provided in chemistry, mineralogy, metallurgy, geology, physics, and civil engineering.

The students of this department receive instruction in an extended course of mechanics as applied to engineering, and their professional preparation comprises the following subjects: The location and construction of railroads, canals, and water works; the construction of foundations in water and on land and of superstructures and tunnels; the surveys, improvements, and defenses of coasts, harbors, rivers, and lakes; the determination of astronomical coördinates; the application of mechanics, graphical statics, and descriptive geometry to the constructions of the various kinds of right and oblique arch bridges, roofs, trusses, and suspension bridges; the design, construction, and application of wind and hydraulic motors; air, electric, and heat engines, and pneumatic works; the drainage of towns and the reclaiming of lands; the preparation of plans and specifications, and the proper selection and tests of the materials used in constructions. As a part of their instruction, students have frequent practice in the preparation of papers on subjects of professional importance.

An elementary course of lectures is given in engineering and mining economy, finance, and jurisprudence.

To meet the growing demand for special training, a five years' course has been arranged allowing considerable option and diversity of studies to students wishing to pursue special lines of study in bridge architecture, or in railroad, mining, topographical, sanitary, geographical, electrical, or industrial engineering. This course also offers lines of continuous study of a historical, literary, or scientific character, which may alternate with the prescribed studies, and with architecture, general science, and technology.

THE COURSES IN CIVIL ENGINEERING.

I.—A FOUR YEARS' COURSE.

(Leading to the degree of bachelor of civil engineering.)

First year.

FIRST TERM.—French *or* German, 5; rhetoric, 2; geometry and conic sections, 5; freehand drawing, 3; hygiene, 6 lectures.

SECOND TERM.—French *or* German, 5; rhetoric, 2; algebra, 5; freehand drawing, 3; linear drawing, 2.

THIRD TERM.—French *or* German, 5; trigonometry, 5; descriptive geometry, text and drawing, 4; botany, 3.

Second year.

FIRST TERM.—French *or* German, 3; analytical geometry, 5; descriptive geometry, text and drawing, 6; experimental mechanics and heat, 3.

SECOND TERM.—French *or* German, 3; calculus, 5; pen topography, 2; tinting and shading, 2; electricity and magnetism, 3; chemistry, 2.

THIRD TERM.—Calculus, 5; land surveying, 4; acoustics and optics, 3; chemistry, 3; technical essays, 1.

Third year.

FIRST TERM.—Calculus, 5; shades, shadows, and perspective, 3; topographical mapping and sketching, 2; lettering, 1; cinematics, *or* physics, laboratory work, 3; technical essays, 1.

SECOND TERM.—Mechanics of engineering, 5; detail drawing and graining, 2; physics, laboratory work, 3; mineralogy *or* metallurgy, 2; geology, 3.

THIRD TERM.—Mechanics of engineering, 5; railroad surveying, 5; colored topography, 3; lettering, 2.

Fourth year.

FIRST TERM.—Mechanics of engineering, 5; spherical astronomy, 5; practical astronomy, night observations, 2; Egyptian, Greek, and Roman architecture, *or* physics, laboratory work, 3; stereotomy and original problems, 3; civil engineering, 2; technical essays, 1.

SECOND TERM.—Hydraulics, 5; higher geodesy, 5; mineralogy *or* metallurgy, 2; stonecutting and original problems and practice, 5.

THIRD TERM.—Hydraulic motors, 2; civil engineering, 3; engineering economy, 2; bridge stresses, 5; hydrographic surveying, chart-making, and geodesy, field work, 3; preparation of thesis.

Students in the courses in civil engineering are required to write memoirs upon professional subjects of their own selection, before the close of the spring term, and these memoirs are presented on the first Friday of the following term. The memoir of the last two years must contain original investigations.

II.—A FIVE YEARS' COURSE.

(Leading to the degree of civil engineer.)

The first four years are the same as in the four years' course. The choice of electives in the fifth year is subject to the approval of the dean of the department.

Students in the fifth year pay no tuition fees and have all the privileges of resident graduates.

Fifth year.

FIRST TERM.—Riparian rights and law of contracts, 3; bridge construction and details, 3; projects, designs, and specifications, 3.

Elective, 9: Greek history, 2; modern history, 3; psychology, 2; American history, 2 or 3; physiology and zoölogy, 5; languages, 2; technical reading, 2; renaissance architecture, 3; chemistry, laboratory work, 3; engineering, laboratory work, 3; physics, laboratory work, 3; rock drills and air compressors, 3; the steam engine, 3; mining projects, 3; geology, 3; industrial chemistry, 3; mathematics, 3.

SECOND TERM.—River and harbor improvements, 3; advanced astronomy and geodesy, 3; technical reading, 2; projects, designs, and specifications, 2.

Elective, 8: Roman history, 2; American history, 2 or 3; political economy, 2; languages, 2; pure or applied mathematics, 5; zoölogy, 3; metallurgy *or* mineralogy, 3; chemistry, laboratory work, 3; engineering, laboratory work, 3; physics, laboratory work, 3; Romanesque architecture, 3; the steam engine, 3; mining projects, 2; industrial chemistry, 3; geology, 3.

THIRD TERM.—Sanitary engineering, 3; locomotive machines, etc., 3; projects, designs, and specifications, 2.

Elective, 6: Roman history, 2; modern history, 3; American history, 2 or 3; languages, 3; pure or applied mathematics, 4; historical or technical reading, 3; geology, 3; chemistry, laboratory work, 3; engineering, laboratory work, 3; physics, laboratory work, 3; Gothic architecture, 3; pumps and small machinery, 2; industrial chemistry, 3; mining projects, 4; arch ribs, 3; geodesy, field work.

MINING ENGINEERING.

Although no department of mining engineering has yet been formally established, all the main instruction required by a mining engineer is now given, as follows: The professor of civil engineering and his associates pay special attention to the needs of those intending to connect themselves with the mining industries, giving lectures on tunneling and on the theory and practice of such constructions as are common to the professions of the civil and mining engineer. The professor of mechanical engineering and his associates pursue a like course, giving instruction in mining machinery. The professors of general chemistry and mineralogy, of analytical chemistry, and of industrial chemistry give instruction in metallurgy, assaying, chemical analysis, and cognate subjects. The professors of geology and palæontology give instruction in the theory and classification of ores and in those branches relating to chemical geology.

It is intended, at an early day, to supplement the existing force by the appointment of such additional professors and lecturers as are necessary to the establishment of a mining school for the most advanced work, both as regards theory and practice. As it is, the university, by its existing provision in the departments named above, is enabled to give such instruction that a student graduating in them can, in a very short time, make him-

self acquainted with the practical processes; and, in all probability, by the time any student now entering the existing departments shall be sufficiently advanced to need instruction in the more elaborate special processes connected with mining, provision will have been fully made to give it.

FREEHAND DRAWING.

Instruction in freehand drawing is given by means of lectures and general exercises from the black-board, from flat copies, and from models. The work embraces a thorough training of the hand and eye in outline drawing, elementary perspective, model and object drawing, drawing from casts, and sketching from nature.

The effort is to render the student familiar with the fundamental principles underlying this art, and to enable him to represent any object he may desire correctly and rapidly. The course is largely industrial, and the exercises are arranged, as far as possible, with special reference to the drawing required in the work of the different departments.

All students in the departments of agriculture, architecture, civil engineering, mechanic arts, mathematics, and natural history devote two hours a day to freehand drawing during the first two terms of the first year; and students in architecture, in addition, two hours a day during one term of the second and one term of the third year. Students in the other courses may take drawing as an elective study.

MATHEMATICS AND ASTRONOMY.

Undergraduates in all the regular courses except natural history have the mathematics of the first year, namely, geometry, algebra, and trigonometry; those in mechanic arts, architecture, and civil engineering have two or four terms of analytical geometry and calculus; those in most of the general scientific courses have analytical geometry and astronomy; and all students have the privilege of electing these and the higher branches. The full course is designed for those intending to teach mathematics in academies and colleges, or to use it as an instrument of investigation. Most of the studies are either directly mathematical or closely connected with mathematics. Substitutes are allowed for nearly all others, so that no exact course is actually pursued by students of mathematics.

PHYSICS.

The instruction comprises a general course of lectures designed as an introduction to the study of the subject, an elementary laboratory course, designed to give a general knowledge of the science, and an advanced laboratory course.

The general course occupies one year, the exercises consisting of two experimental lectures and one recitation weekly. The subjects are pursued as follows: first term, experimental mechanics and heat; second term, electricity and magnetism; third term, acoustics and optics. A knowledge of mathematics through plane trigonometry is required for registration in either of the subjects; and for registration in electricity and magnetism and in acoustics and optics a knowledge of experimental mechanics and heat is also required.

The elementary laboratory course consists of a series of simple experiments arranged to perfect and fix the student's knowledge of physical facts and laws, and at the same time give him some experience in physical manipulation. The course occupies seven and one-half hours a week (equivalent to three hours of lectures) for one year.

Students are admitted to the laboratory to pursue only such subjects as they have completed in the general course of lectures.

The advanced laboratory course consists of a series of experiments for the establishment of physical laws and the determination of constants. Many of these experiments involve the most refined methods of measurement. Students entering this course are expected to devote to it at least seven and a half hours a week. They may enter for one or more terms at their option, and may, within certain limits, elect the line of work they wish to pursue. Special students will devote a part of their time to an original investigation.

CHEMISTRY AND MINERALOGY.

I.—DESCRIPTIVE AND THEORETICAL CHEMISTRY.

The instruction begins with lectures on inorganic chemistry. Three lectures a week are given on the theoretical principles and the general study of the chemistry of inorganic bodies. During the first term of the third year a course of lectures is given on the chemistry of organic bodies.

For laboratory instruction in this branch of the subject a course of introductory practice is given in the third term of the second year. This introductory practice consists in the performance by the student of a series of experiments illustrating the more important general principles of the science. The details of the manipulation of each experiment are carefully described, but the results to be obtained are not given. For the better cultivation of the student's powers of observation he is required to observe and describe these results for himself, and trace their connection with the principles which they are intended to illustrate.

The instruction in theoretical chemistry is continued in the course in chemistry and physics by recitations in chemical philosophy and by lectures on organic chemistry.

Metallurgy and mineralogy.—During the second term two lectures a week are devoted to each of these subjects in alternate years. The course in metallurgy is intended to give the students in the technical courses a general idea of fuels, ores, and the most important methods of extracting the various metals which are especially used in construction, the metallurgy of iron claiming naturally the most attention. A certain amount of laboratory work in blowpipe analysis, with practice in the identification of crystalline forms, is required in connection with the lectures on mineralogy.

II.—ANALYTICAL CHEMISTRY.

The course in analytical chemistry, beginning in the second year, comprises qualitative and quantitative analysis both in the wet way and in the dry way (blowpipe analysis and assaying), and is adapted in respect to length and completeness to the special course of study the student is pursuing.

In the course of chemistry and physics, leading to the degree of B. S., the qualitative analysis in the wet way and the blowpipe analysis are taken in the first two terms, beginning with the second term of the second year. This work may or may not, according to the proficiency attained in these two terms, extend into the following term. In connection with the quantitative work, which occupies at least a large part of the time devoted to chemical practice in the third and fourth years of this course, some practice in qualitative analysis is continued.

The quantitative work begins with general practice in the determination of bases and acids by gravimetric and volumetric methods, after which follow the analysis of minerals, ores, and technical products in the wet way, and dry assaying, organic ultimate and proximate analysis, the analysis of gaseous mixtures, the chemical examination of waters and articles of food, spectroscopic analysis, the preparation of substances, and, finally, the thesis for graduation, to which most of the time of the last two terms of the course should be devoted.

In the course in agriculture the analytical practice of agricultural chemistry begins in the first term of the second year, and comprises analysis in the wet way only; it is confined to those substances that may occur in agricultural materials and products. The qualitative analysis should be completed in two terms of this year, so that all the time given to the subject in the third year may be devoted to quantitative analysis. This quantitative work begins, as in the course in chemistry and physics, with general practice in the determination of bases and acids by gravimetric and volumetric methods. The chemical examination of fertilizers, soils, and agricultural products occupies the remainder of the course.

In the course in civil engineering a course of practice in blowpipe analysis is provided, which is intended to give to engineers such facility in the use of the blowpipe in determinative mineralogy as will enable them to avail themselves of this useful instrument in their field work, for the determination of the character of rocks and minerals.

In the medical preparatory course a short course of qualitative and quantitative analysis in the wet way is given, which may carry the student far enough to qualify him to examine animal liquids by chemical methods for assistance in the diagnosis of disease. The amount of practice necessary for acquiring merely the rudiments of chemical analysis renders it impracticable to accomplish more than this in the time allotted in the course. Students intending to study medicine who have more time for chemical practice can take a longer and more thorough course, which includes a better foundation in quantitative work and a wider application of the proficiency thus gained to the chemical examination of animal substances and articles of food and drink, and to medical jurisprudence.

III.—INDUSTRIAL CHEMISTRY.

A course of lectures is given in the third term of each year, and the subject is begun anew every second year.

The lectures relate to the applications of chemistry in the manufacturing industries and in daily life, and include among others the following subjects: acids and heavy

chemicals, soaps, oils, coal gas, coal tar and its derivatives, glass, pottery, mortar and cement, leather, paper, paints, dyes and dyeing, alcoholic liquors, food, water, and air.

The treatment of these subjects embraces the consideration of the chemical nature of raw materials and the changes which they undergo in the course of manufacturing processes, the apparatus used and its resistance to chemical agents, the utilization or economical disposition of wastes, and the perfection and purity of finished products. The subjects of food, water, and air are also considered from a chemical standpoint with reference to their sanitary and industrial relations.

In connection with these lectures a course of laboratory work is provided, which bears upon the industrial applications of chemistry; and special courses are laid out for students with reference to the needs of any branch of industry they may select. This work consists of analyses of raw materials and commercial products, determinations necessary to the chemical control of a technical process in its different stages, and, when the student is sufficiently prepared, of original investigation with a view to the improvement of some industrial method.

Practical illustration of the different subjects treated is furnished not only in the collections belonging to the department, but also by means of excursions to mills and manufactories.

THE COURSE IN CHEMISTRY AND PHYSICS.

(Leading to the degree of bachelor of science.)

First year.

FIRST TERM.—French, 5, and German, 3, *or* German, 5, and French, 3; rhetoric, 2; geometry and conic sections, 5; hygiene, 6 lectures.

SECOND TERM.—French, 5, and German, 3, *or* German, 5, and French, 3; rhetoric, 2; algebra, 5.

THIRD TERM.—French, 5, and German, 3, *or* German, 5, and French, 3; rhetoric, 2; trigonometry, 5.

Second year.

FIRST TERM.—French *or* German, 3; composition and elocution, 1; analytical geometry, 5; experimental mechanics and heat, 3; chemistry, laboratory work, 3.

SECOND TERM.—French *or* German, 3; electricity and magnetism, 3; chemistry, lectures, 3, laboratory work, 8.

THIRD TERM.—French *or* German, 3; acoustics and optics, 3; chemistry, lectures, 3, laboratory work, 5; botany, 3.

Third year.

FIRST TERM.—Physics, laboratory work, 3; chemical philosophy, 3; chemistry, laboratory work, 7; geology, 3.

SECOND TERM.—Physics, laboratory work, 3; chemical philosophy, 3; organic chemistry, 1; chemistry, laboratory work, 5; mineralogy *or* metallurgy, 2; economic geology, 3.

THIRD TERM.—Physics, laboratory work, 3; chemical philosophy, 3; industrial chemistry, 2; chemistry, laboratory work, 7.

Fourth year.

FIRST TERM.—Physics, laboratory work, 4; organic chemistry, 1; chemistry, laboratory work, 8; history of philosophy, 3.

SECOND TERM.—Physics, laboratory work, 4; organic chemistry, 2; chemistry, laboratory work, 8; metallurgy *or* mineralogy, 2.

THIRD TERM.—Industrial chemistry, 2; chemistry, processes, 2, laboratory work, 8; organic chemistry, 1.

NATURAL HISTORY.

I.—BOTANY.

A course of lectures occupying 5 hours a week for 2 years is given upon each of the following subjects: physiological botany, gramineæ and compositæ, vegetable physiology, vegetable histology, systematic and applied botany, higher cryptogamia, fungi, and algæ. Most of these courses of lectures are given in connection with laboratory work, which is further supplemented, whenever desirable, by field work or class excursions.

II.—GEOLOGY AND LITHOLOGY.

Instruction is given in general and economic geology and lithology by means of lectures, laboratory practice, and field work. The lectures consist of a course on general geology, a course on economic geology, and a course on physical geography, designed to show the action of geological agencies in fitting the earth for human habitation.

The laboratory work consists of a progressive series of exercises in determinative mineralogy and lithology, and of exercises in the preparation of geological sections and maps from the data furnished by government reports. There are frequent excursions and lessons in field work.

To advanced students opportunities are offered for the microscopic investigation of minerals and rocks, and for the extended study of important mineral districts, with the preparation of reports thereon and discussions of the metallurgical methods and appliances adapted to their products. The rocks of Ithaca and its neighborhood afford ample material for study and original research.

III.—PALÆONTOLOGY.

Instruction is given as follows: By laboratory work throughout the year; by excursions to the rich fossiliferous localities in and about Ithaca; and by lectures on systematic palæontology.

The elementary work comprises the observation and recording of facts, the collecting of material in the field, the critical study of the literature and the classification in the laboratory of invertebrate fossils from all parts of the world.

Exceptional facilities are offered for advanced work in the interpretation of fossil forms as marks of geological age and sequence; in the study of faunas, their conditions and distribution; and in the critical study of species and genera, their characters, relations, and modifications, as exhibited in the faunas and floras of the past.

IV.—ZOÖLOGY.

1. *Hygiene.*—Early in the first term are given six lectures upon the personal care of health and upon emergencies. Among other practical matters, students are shown how to check bleeding and how to practice the best methods for resuscitating the drowned.

2. *Human physiology.*—The thirty-six lectures treat chiefly of the subjects not included in the entrance examination, the phenomena of nervous and muscular action, the vaso-motor system, and the structure and functions of the brain. They are illustrated by a life-sized manikin and other models, by numerous anatomical preparations, by diagrams, and by painless experiments upon the frog and cat. Each student also examines, through the microscope, about thirty preparations of the tissues, including the living amœba, cilia in action, and the circulation in the frog's foot and menobranchus's gill.

3. *General zoölogy.*—At one-third of the sixty-six exercises the students examine and dissect representative forms, including amphioxus, lamprey, shark, perch, menobranchus, frog, turtle, squid, crayfish, insect, clam, bryozoön, ascidian, starfish, &c. The lectures are illustrated by a full set of Auzoux models, by diagrams, and by the free use of the zoölogical collections.

4. *Comparative anatomy.*—A course of twenty lectures is devoted either to the brain or to some special group of vertebrates. In either case, practical work is done both in dissecting and in the examination of the literature of the subject.

5. *Anatomical, microscopical, and experimental technology.*—The forty lectures upon these subjects are accompanied by practical demonstrations of all the methods presented, and these methods are employed by the students in the laboratory.

LABORATORY PRACTICE.—The laboratory practice varies with the needs of the student and the extent of his preparation. Usually, as a basis for other work, the skeletons of man and the domestic cat are studied, and some of the bones drawn and described by the student. He then dissects some of the muscles, vessels, and nerves. In the second term, the methods of microscopic manipulation are learned, and the tissues of the cat, frog, and menobranchus are examined. In the third term the student examines the brain, heart, and other viscera of the cat, and performs for himself the simpler physiological experiments. Ordinarily this work can be commenced only at the beginning of the year, and the student must have had instruction in drawing.

After the first year the student, according to his purposes, dissects other vertebrate animals or human subjects, or insects and other invertebrates. There are special facilities for the study of the vertebrate brain.

FIELD WORK.—During the first and third terms students are occasionally accompanied by their instructors to the field or lake in order to observe living animals and learn the methods of their capture and preservation.

THE COURSE IN NATURAL HISTORY.

(Leading to the degree of bachelor of science.)

First year.

FIRST TERM.—French, 5, and German 3, *or* German, 5, and French, 3; rhetoric, 2; freehand drawing, 5; hygiene, six lectures.

SECOND TERM.—French, 5, and German, 3, *or* German, 5, and French, 3; rhetoric, 2; chemistry, lectures, 3, laboratory work, 3.

THIRD TERM.—French, 5, and German, 3, *or* German, 5, and French, 3; rhetoric, 2; chemistry, lectures, 3, laboratory work, 3.

Second year.

FIRST TERM.—French *or* German, 3; composition and elocution, 1; organic chemistry, lectures, 2; human physiology, 3; zoölogy, lectures and laboratory work (vertebrates), 3; anatomy, laboratory work, 2; anatomical technology, 1.

SECOND TERM.—French *or* German, 3; composition and elocution, 1; zoölogy, lectures and laboratory work (invertebrates), 3; laboratory work in physiological anatomy and histology, 5; microscopical technology, 1; blow-pipe determination of minerals, 3.

THIRD TERM.—French *or* German, 3; composition and elocution, 1; botany, lectures, 3; field-work, 2; comparative anatomy of the brain, lectures, 2; laboratory work, 3; museum methods and experimental technology, 1.

Third year.

FIRST TERM.—Experimental mechanics and heat, 3; higher cryptogamia, lectures and laboratory work, 2; compositæ and gramineæ, 2; geology, 3; psychology, 2; essays, 1; English literature, 3.

SECOND TERM.—Electricity and magnetism, 3; vegetable physiology, *or* systematic and applied botany, 3; vegetable histology, 2; economic geology, 3; palæontology, lectures, 2, laboratory work, 1; essays and orations, 1.

THIRD TERM.—Acoustics and optics, 3; algæ, lectures and laboratory work, 2; palæontology, laboratory, and field work, 3; geology, laboratory work, 3; entomology, lectures, 2; laboratory and field work, 3.

Fourth year.

FIRST TERM.—Fungi, 4; the anatomy, physiology, and hygiene of domestic animals, lectures, 5; palæontology *or* geology, laboratory and field work, 3; history of philosophy, 3.

SECOND TERM.—Descriptive astronomy, 3; physics *or* natural history, laboratory work, 2; systematic and applied botany *or* vegetable physiology, lectures, 3; geology or palæontology, laboratory work, 2; advanced work in natural history *or* veterinary science, 5.

THIRD TERM.—Physical astronomy, 3; physics or natural history, laboratory work, 2; advanced work in natural history *or* veterinary science, 8.

PRELIMINARY MEDICAL EDUCATION.

There is no medical department of the university, but special facilities are provided for those who wish their course to be of direct use in the study of medicine. A course of preparatory studies two years in length is offered. Its principal studies are French, German, physics, chemistry, botany, anatomy, and physiology.

Upon the completion of this course the student is entitled to a certificate countersigned by the professor in physiology, or to one covering an equivalent amount of similar work done in either of the full four-year courses or in one of the graduate courses. These certificates usually exempt the holder from one of the three years of study, under the direction of a physician, commonly required of the candidate for a medical degree.

LANGUAGES AND LITERATURE.

The departments of languages and literature provide thorough and comprehensive instruction in all branches connected with those subjects. There are courses in (1) the ancient languages; (2) the Oriental languages; (3) the Germanic languages; (4) the romance languages; (5) Anglo-Saxon and English literature; and (6) rhetoric, general literature, and oratory.

In turning from the scientific to the literary courses of Cornell University, it may not be out of place to introduce some remarks from a recent article in the Unitarian Review by the Rev. Henry C. Badger:

"No error is greater than to suppose that Cornell University is but a training school for mechanics. Many believe, with Matthew Arnold, that 'the university of Mr. Ezra Cornell, a really noble monument of his munificence, yet seems to rest on a provincial misconception of what culture truly is, and to be calculated to produce miners, or engineers, or architects, not sweetness and light.' But Mr. Cornell knew the full meaning of his words now set on the college seal, and the 'instruction' he wished any person might find here in any study was to be all-embracing, nor yet surface-building, with no attempt to dig to the rock. And instruction was to be but one step in education. Culture was a word of which Mr. Cornell was not afraid nor ashamed. He knew its best meaning.

"Studies are practical here. A brass foundry Mr. Sibley's generosity has just annexed to Sibley College. Young women may set type and cast stereotype plates. Young men build steam-engines and electrical machines. The telephone speaks from the president's house to the library, the business office, the professors' houses, and to the far-off village. The water power, singing in the gorges which bound the college grounds, by day turns the machinery in Sibley College and at night keeps a grand electric light gleaming high above the campus and far over the surrounding country. It may soon light all the great college buildings and the many professors' houses scattered about this hundred-acre campus. So a very few young men learn, on the college farm, how to repress diseases and develop the finer qualities of animals, grains, and fruits. But the thorough studies in anatomy (justifying the future founding here of a medical college) or in botany, chemistry, physics, architecture, engineering, mathematics, and in all allied branches, with their separate professors and colleges, make but the lower section of the studies here happily pursued. In certain particulars, like the ancient languages, the university meets the demand, in others it creates the demand. Probably nowhere else in America is the study of history, with all that it involves, carried on with greater method and thoroughness than here."*

The truth of the last sentence is brought out as we proceed with the courses of study.

MORAL AND INTELLECTUAL PHILOSOPHY.

Instruction in philosophy begins in the first term of the third year. During that term it comprises a study of the physiology of the nervous system in relation to mental phenomena, and the nature and origin of knowledge; and during the second term, the study of moral philosophy, theories of morals, and the development of moral sentiments.

It is resumed the third term, the subject being logic, including the laws of thought, the formulæ of reasoning, and the various methods of proof and refutation, together with the methods of investigation and the grounds of certainty.

The subject during the first term of the fourth year is the history of philosophy, and the progress of knowledge from its beginning in Greece to the present day, with criticisms on the methods of philosophy and transcendental logic.

HISTORY AND POLITICAL SCIENCE.

I.—HISTORY.

The aim in the courses of instruction in history is to present in logical and chronological sequence:

1. General history, ancient, mediæval, and modern, with especial reference to the political and social development of the leading nations.
2. The constitutional history of England, as that which has most strongly influenced our own.
3. The comparative constitutional and legislative history of various modern states, as eliciting facts and principles of use in solving American problems.
4. The history, political, social, and constitutional, of the United States, with a systematic effort to stimulate the student to original research into the soures of our national history.
5. The philosophy of history, as shown by grouping the facts and thoughts elicited in these various courses.

General history.

The instruction in general history extends through four years, as follows:

1. General ancient, Grecian, and Roman history, beginning with the third term of the first year and continuing through the three terms of the second year.
2. Mediæval history: General history of the social and political development of Europe

*Unitarian Review, October, 1882, pp. 320-321.

during the Middle Ages, mainly by instruction in general English history during the first and second terms of the second year, and by special lectures in the third year.

3. Modern history: The history of the political and social development of Europe from the close of the Middle Ages to the present day, with especial reference to the Reformation, the Reaction, the French Revolution, the Napoleonic era, and the recent period, divided as follows:

FIRST TERM.—The history of Germany begun.

SECOND TERM.—The history of Germany concluded, and the history of France begun.

THIRD TERM.—The history of France concluded, with incidental lectures on important points and periods in the history of Italy and Spain.

English history.

The instruction in English history is given by recitations from text-books during the entire second year, and by courses of lectures on the growth and principles of the Constitution during the third year. The student is expected to supplement these lectures by the use of some standard work for general details, and of monographs on particular subjects and epochs. While avoiding the more obscure technicalities, the aim is to present the great bases of law and policy on which the structure of the English Government rests. The early Saxon institutions are described at some length; and the lectures follow the development of the system from this germ through its leading phases down to modern times. Special attention is paid, during the whole course, to such topics as illustrate the institutions and constitutional history of the United States.

Comparative, constitutional, and legislative history.

This subject is treated, as far as possible, in the courses of lectures upon modern history in the third year, and in a special course of lectures during the fourth year.

American history.

The study of American history extends through the third and fourth years. The topics to which particular attention is paid are the following: The native races, especially the mound builders and the North American Indians; the alleged pre-Columbian discoveries; the origin and enforcement of England's claim to North America as against competing European nations; the motives and methods of English colony-planting in America in the seventeenth and eighteenth centuries; the development of ideas and institutions in the American colonies, with particular reference to religion, education, industry, and civil freedom; the grounds of inter-colonial isolation and of inter-colonial fellowship; the causes and progress of the movement for colonial independence; the history of the formation of the national Constitution; the origin and growth of political parties under the Constitution; the history of slavery as a factor in American politics, culminating in the civil war of 1861-1865.

In the presentation of these topics the student is constantly directed to the original sources of information concerning them and to the true methods of historical inquiry. The effort is also made to use American literature as a means of illustrating the several periods of American history.

Philosophy of history.

The lectures on this subject are given in the second term of the fourth year. Their object is to trace the origin and progress of civilization, and to point out the causes and institutions, civil, social, and religious, which have contributed to its advance or tended to retard its progress. The first half of the course treats of general principles, and the latter half, of the historic progress in civilization, beginning with the settlement of the Aryan nations in Europe.

II.—POLITICAL AND SOCIAL SCIENCE.

This division includes the following topics:

1. Political economy and the history and principles of finance.
2. Theoretical politics, or the state philosophically considered.
3. Systematic politics, or the state practically considered in respect to the organization of the various functions.
4. International law, including American diplomatic history, policy, and organization.
5. American law and jurisprudence.

Political economy.

The instruction in political economy is given by recitations from text books in the elements of the science, and by a course of lectures in which practical questions arising in the study of industrial society receive attention. A course of lectures upon the science of finance, embracing a study of the comparative financial administration of constitutional nations and the various sources of public revenue, is given. Both these courses of lectures are to be supplemented by private reading.

Theoretical and systematic politics.

The aim of the instruction in political science proper is to present both the philosophical and the practical side of the subject in a logical order of treatment. It comprises the two general topics of theoretical and systematic politics.

Theoretical politics treats of primitive societies, the growth of states, forms of government, history of political literature and speculation, and the philosophy of the state.

Systematic politics treats of states in their concrete relations, and includes such subjects as constitutional organization, legislation, administration, and civil-service methods, justice, revenue, military systems, and a comparative survey of existing governments. The historical and the analytical methods are both used, and the object of the course is to make the student acquainted in a scientific sense with the true principles of political organization and practice, as well as with the existing institutions of the great civilized states.

International law and diplomacy.

Instruction in this department consists of a course of lectures given daily during the third term of the fourth year. The course treats, among other subjects, of the history and literature of the law of nations, rules of war, neutrality, prize, embassy, forms of diplomacy, history of American diplomacy, together with descriptions of some of the more famous international disputes in which the United States have been concerned.

American law and jurisprudence.

The course consists of about forty lectures. The first three are devoted to the more general relations of man to government; then follow twelve lectures on the Constitution of the United States, and five on the origin and development of international law; then lectures on the rights of persons and of property, with a general discussion of the nature of contracts, partnerships, and corporations; then lectures on crimes and criminal law; and the course concludes with four lectures on the legal maxims relating to sovereignty, legislation, customary law, and the judiciary.

THE COURSE IN HISTORY AND POLITICAL SCIENCE.

(Leading to the degree of bachelor of philosophy.)

First year.

FIRST TERM.—French *or* German, 5; Latin, 4; rhetoric, 2; geometry and conic sections, 5.

SECOND TERM.—French *or* German, 5; Latin, 4; rhetoric, 2; algebra, 5.

THIRD TERM.—French *or* German, 5; Latin, 4; rhetoric, 2; pre-historic times, 2; plane trigonometry, 3.

Second year.

FIRST TERM.—French and German, 6; essays, 1; Grecian history, 2; English history, 3; Greek, Latin, modern languages, mathematics, *or* natural sciences, 3.

SECOND TERM.—French and German, 6; essays, 1; Roman history, 2; English history, 3; Greek, Latin, modern languages, mathematics, *or* natural sciences, 6.

THIRD TERM.—French and German, 6; essays, 1; Roman history, 2; English history, 3; theory of probabilities and statistics, 3.

Third year.

FIRST TERM.—Mediæval and modern history, 3; English constitutional history, 2; American history—pre-historic America and the period of discovery, 3; psychology, 2; sanitary science, labor laws, and penal discipline, 2; essays, 1; elective, 3.

SECOND TERM.—Modern history, 3; American history—the planting of the American colonies, 3; political economy, 2; moral philosophy and political ethics, 2; essays and orations, 2; elective, 3.

THIRD TERM.—Modern history, 3; American history—the institutions of the colonial times, 3; logic, 3; political economy, 2; essays and orations, 2; elective, 3.

Fourth year.

FIRST TERM.—American history—the period of the Revolution, 1765–1789, 3; history of philosophy and the natural sciences, 3; theoretical politics, 3; finance and political economy, 5; general literature and oratory, 3.

SECOND TERM.—American history—first national period, 1789–1820, 3; philosophy of history, 3; systematic politics, 5; comparative constitutional history, 2; general literature and oratory, 3.

THIRD TERM.—American history—second national period, 1820–1865, 3; comparative constitutional history, 2; American law and jurisprudence, 5; international law and diplomacy, 5; orators and oratory, 1.

GENERAL COURSES OF STUDY.

In addition to the special departments and courses which have been described there are general courses, partly made up from the various departments of study and partly elective. They are in (1) arts, (2) literature, (3) philosophy, (4) science, and (5) science and letters. Each is four years in length.

APPLIANCES.

I. THE UNIVERSITY BUILDINGS.

1. *The south and north buildings:* These two edifices, architecturally alike, are each one hundred and sixty-five feet by fifty, four stories in height. The south building cost $70,000; the north, $75,000. The south building contains the offices of the president, treasurer, &c., lecture rooms, and rooms for students. In the north building are fourteen lecture rooms and the hall of the literary societies.

2. *The McGraw building:* The central portion of the building contains one hall one hundred feet long, fifty-six wide, and nineteen in height; and another above it of the same length and breadth, but over thirty feet high, the latter containing three galleries, with an average height of twelve feet. In this part of the McGraw building are alcoves and galleries for the library on the lower floor; and in the galleries on the second floor are the various museums of the university. In the north wing is the anatomical theatre; in the south wing is the physical lecture room, and immediately over it the geological laboratory. This edifice is the gift of Hon. John McGraw, and was erected at a cost of $120,000.

3. *The laboratory building:* A new building for the department of chemistry and physics has recently been begun, and will be ready for occupation about January, 1883. This building will contain all the necessary space for a museum, a library, laboratories, lecture rooms, and other rooms, and will be thoroughly equipped with the most recent and approved appliances for the proper prosecution of the work of the department.

The chemical laboratory now in use contains, besides two lecture rooms and the private laboratories of the professors, laboratories for students, with accommodations for two hundred. It is provided with gas and a full supply of apparatus for wet analysis, dry assaying, blowpipe, spectroscopic, and all other branches of chemical analysis. Its reading room contains the best English, French, and German works of reference, and the current numbers of the chemical journals.

4. *The Sibley College:* Containing, on the first floor, the machine shop and the office of the university press; on the second floor, the lecture rooms of the professor of industrial mechanics and the mechanical museums; on the third floor, the mechanical and free-hand drawing rooms. On the north side of the building are an engine room and a stereotype foundery. The building was erected by Hon. Hiram Sibley, at a cost of $30,000.

5. *The Sage College for Women:* This building will accommodate about one hundred pupils, and is used as a home for female students. Besides the dormitories it contains lecture and recitation rooms, a museum, laboratories for students in botany, with greenhouses, forcing-houses, and other facilities for the pursuit of floriculture and ornamental gardening. The building cost $150,000.

6. *The Sage Chapel:* Which contains two audience rooms, the larger of which will seat about five hundred persons. It cost $30,000.

7. *Cascadilla Place:* This is a large building, used for a boarding-house, in which many of the professors and students reside.

8. *The McGraw-Fiske Hospital:* In the year 1881, the sum of $45,000 was bequeathed by Mrs. Jenny McGraw-Fiske as a provision for the care of students who may fall ill during their attendance at the university. It is proposed that a portion of this sum be devoted to the erection of a cottage hospital, made comfortable and attractive, and thoroughly equipped in all respects; and that a trained nurse be attached to it, who shall be ready to give attention the moment it is needed.

II.—UNIVERSITY FARM.

The farm consists of 120 acres of arable land, the larger part of which is used for experimental purposes and the illustration of the principles of agriculture. Nearly all the domestic animals are kept to serve the same ends. Those portions of farm and stock not used for experiments are managed with a view to their greatest productiveness. Statistics of both experiments and management are kept on such a system as to show at the close of each year the profit or loss not only of the whole farm but of each crop and group of animals. Of the two barns with which the farm is equipped, one is largely devoted to the needs of the horticultural department; the other, containing steam engine, feed cutter, stationary thresher, and other necessary appliances, furnishes accommodation for the general crops and stock and for experimental work.

III.—LIBRARIES, LABORATORIES, MUSEUMS, ETC.

1. *The University Library.*—The library contains about 40,000 volumes, besides 15,000 pamphlets. It is made up chiefly of the following collections: A selection of about 5,000 volumes purchased in Europe in 1868, embracing works illustrative of agriculture, the mechanic arts, chemistry, engineering, the natural sciences, physiology, and veterinary surgery; the *Anthon Library*, of nearly 7,000 volumes, consisting of the collection made by the late Prof. Charles Anthon, of Columbia College, in the ancient classical languages and literature, besides works in history and general literature; the *Bopp Library*, of about 2,500 volumes, being the collection of the late Prof. Franz Bopp, of the University of Berlin, relating to Oriental languages, Oriental literature, and comparative philology; the *Goldwin Smith Library*, of 3,500 volumes, presented in 1869 to the university by Prof. Goldwin Smith, comprising chiefly historical works and editions of the English and ancient classics, increased during later years by the continued liberality of the donor; the publications of the patent office of Great Britain, about 3,000 volumes, of great importance to the student in technology and to scientific investigators; the *White Architectural Library*, a collection of over 1,000 volumes relating to architecture and kindred branches of science, given by President White; the *Kelly Mathematical Library*, comprising 1,800 volumes and 700 tracts, presented by the late Hon. William Kelly, of Rhinebeck; the *Cornell Agricultural Library*, bought by Hon. Ezra Cornell, chiefly in 1868; the *Sparks Library*, being the library of the late Jared Sparks, president of Harvard University, consisting of upwards of 5,000 volumes and 4,000 pamphlets, relating chiefly to the history of America; the *May Collection*, relating to the history of slavery and anti-slavery, the nucleus of which was formed by the gift of the library of the late Rev. Samuel J. May, of Syracuse.

By the establishment of the McGraw library fund, the income of which will be available after the present year, and which is to be applied to the support and increase of the University Library, the efficiency of the library both as regards the number of books and the facilities for their use will be greatly enlarged. Beginning with the year 1882, it is proposed to issue a serial containing classified lists of recent accessions and of books in various departments, as well as other bibliographical matter intended to assist students in their use of the library.

The library is a circulating one so far as the members of the faculty are concerned, and a library of reference for students. Undergraduates have free access to a collection of cyclopædias, dictionaries, and works of reference in the various departments of study, but they apply to the librarians for other works desired. Graduate students are admitted to the alcoves.

2. *Equipment.*—The White Architectural Library contains over 1,000 volumes, and the photographic gallery nearly 2,000 prints, all accessible to the student. Several hundred drawings and about 200 models in wood and stone have been prepared to illustrate the constructive forms and peculiarities of the different styles.

3. The library of the engineering department possesses many valuable works, among them the extensive publications recently presented to it by the French Government.

4. *Botanical herbarium and apparatus.*—The means of illustrating the instruction in botany include the herbarium, estimated to contain above 20,000 specimens; two series

of models, the Auzoux and the Brendel; two sets of maps, one by Achille Comte, the other by Professor Henslow; a lime lantern with 500 views, illustrating different departments of botany, but especially phytography; ten compound microscopes and several dissecting microscopes; a collection of fruits, barks, cones, nuts, seeds, fibres, and various dry and alcoholic specimens; a general collection of economic vegetable products, and above a thousand specimens of the woods of different countries. Besides these, the large conservatories and gardens and an uncommonly rich native flora afford abundant material for illustration and practical work.

5. *Veterinary Museum.*—The museum embraces the following collections:

(1) The Auzoux veterinary models, comprising clastic models of the horse, sho wingthe relative position of over 3,000 anatomical parts; models of limbs, sound and with detachable pieces and their morbid counterparts, illustrating changes in diseases of the bones, joints, muscles, &c.; a set of obstetrical models, showing the virgin and gravid uterus in different animals, and the peculiarities of the female pelvis and its joints; models of the gastric cavities of domestic animals; an extensive set of models of jaws, showing the indications of age as well as of vicious habits and diseases; models of equine teeth in sections, showing structure and the changes effected by wear.

(2) Skeletons of the domestic animals, articulated and unarticulated.

(3) A collection of diseased bones, illustrating the various constitutional diseases which impair the nutrition of these structures, together with the changes caused by accidental injuries and purely local disease.

(4) Skulls of domestic animals, prepared to illustrate the surgical operations demanded in the different genera.

(5) Jaws of farm animals, illustrating the growth and wear of the teeth, age, dentinal tumors, caries, &c.

(6) A collection of specimens of teratology, consisting of monstrous foals, calves, and pigs.

(7) A collection of tumors and morbid growths removed from the different domestic animals.

(8) Some hundreds of specimens of parasites from domestic animals.

(9) A collection of calculi from the digestive and urinary organs, &c., of farm animals.

(10) Foreign bodies taken from various parts of the animal economy.

(11) A collection of surgical instruments used in veterinary practice.

(12) A collection of medicinal agents.

(13) In addition, a large number of diagrams, the property of Professor Law, available in illustration of different points in anatomy, physiology, and pathology.

6. *Zoölogical Collections.*—(1) *Vertebrates.*—There are about three thousand examples of about two thousand species of entire animals in alcohol. Half of the specimens are fishes collected in Brazil by the late Prof. C. F. Hartt; the remainder include series of named fishes from the Smithsonian Institution and the Museum of Comparative Zoölogy, representatives of the general North American fauna and of the local fauna, and rare specimens from various parts of the world. Among the last are the following:

(*a*) Orang, pangolin, sloths, ant-eaters, armadillos, jacana, sphenodon, monitor, crocodile, alligator, draco volans, axolotl, siren, amphiuma, pipa, ceratodus, polypterus, calamoichthys, chimæra, myxine, bdellostoma, and amphioxus.

(*b*) More than two thousand anatomical preparations, about one-half of which are skulls and skeletons; the remainder, brains, hearts, embryos, and other soft parts. Among them are more than two hundred and twenty preparations of the cat's brain, a large series of preparations of the lamprey and menobranchus, and embryos or young of opossum, kangaroo, manatee, dugong, peccary, lama, sea-lion, bat, alligator, menobranchus, amia, lepidosteus, shark, and skate.

(*c*) About four hundred microscopical preparations, chiefly from the cat, frog, and menobranchus.

(*d*) More than one thousand mounted skins of birds, most of which were presented by the late Green Smith, esq.

(2) *Invertebrates.*—The general invertebrate collection comprises a small but well selected series of forms representing all of the larger groups.

(3) *Shells.*—The Newcomb collection of shells embraces more than eighty thousand examples of more than twenty thousand varieties, representing at least fifteen thousand species.

7. *Museum of Palæontology.*—The museum comprises the following collections:

(1) The *Jewett Collection*, accumulated by the late Colonel Jewett when curator of the State Cabinet of Natural History. This collection is especially rich in New York fossils, containing many of the original specimens described in the State reports, and not a few unique specimens.

(2) A fair representation of the rich faunas of the cretaceous and tertiary formations

along the eastern and southern part of the Union, and a large number of characteristic English and European fossils.

(3) A fine series of English mesozoic fossils; of tertiary fossils from Santo Domingo: of preglacial fossils from Sweden; and numerous smaller collections from various typical localities in our own country.

(4) The Ward series of casts.

(5) The unique collections from Brazil, made by Professor Hartt and party on the Morgan expedition, containing the original specimens and a great number of duplicates.

The palæontological laboratory is furnished with the appliances needful for study. Among other thing, it has numerous maps, wall tablets, engravings of geological objects, and magic lantern slides.

Large and important additions have also been made to the lithological collections.

8. *Engineering Museum.*—This museum contains the following collections, which receive regular additions from a yearly appropriation:

(1) The Muret collection of models in descriptive geometry and stone cutting.

(2) The De Lagrave general and special models in topography, geognosy, and engineering.

(3) A nearly complete collection of the Schroeder models in descriptive geometry and stone cutting, with some of the Olivier models, and others made at the university.

(4) The Grund and Sohn collections of bridge and track details, roofs, and trusses, supplemented by similar models by Schroeder and other makers.

(5) A complete railroad bridge of one hundred foot span, the model being one-fourth of the natural scale.

(6) The Digeon collection of working models in hydraulic engineering.

(7) Several collections of European photographs of engineering works during the proeess of construction, and many other photographs, diagrams, and models.

(8) The following instruments of precision for astronomical purposes: A Troughton & Simmss transit, a universal instrument by the same makers reading to single seconds, three sextants, two astronomical clocks, chronographs, chronometers, two small equatorials, the larger of four and a half inch aperture, made by Alvan Clark, and other instruments necessary to the equipment of a training observatory.

(9) For geodetic work, a secondary base line apparatus, made under the direction of the Geodetic and Coast Survey Office, and all the portable astronomical and field instruments needed, including sounding machines, deep-water thermometers, heliotropes, &c.

(10) Among the coarser field instruments there is nearly every variety of engineers' transits, theodolites, levels, and compasses; such modern instruments as omnimeters tachometers, with a large number of special instruments, such as planimeters, pantographs, elliptographs, arithmometers, pocket altazimuths and sextants, hypsometers, and meteorological instruments of all descriptions.

9. *Physical Laboratory.*—Upon the completion of the new building now in progress, ample rooms expressly designed for laboratory work will be available. The collection of apparatus was increased by the expenditure during 1881 of about $15,000. The collection includes a fine gravity escapement clock, a chronograph for measuring tenths of seconds, and another for measuring short intervals of time to the ten thousandth of a second, two cathetometers, a dividing engine, a large spectrometer reading to seconds, a set of apparatus for electrical measurements, besides a large collection of illustrative apparatus.

10. *Mechanical laboratory and appliances.*—The machine shop is used for the sole purpose of giving instruction in practical work. It is supplied with lathes of various kinds, planers, grinding machinery, drilling machines, shaping machines, a universal milling machine fitted for cutting plane, bevel, and spiral gears, spiral cutters, twist drills, with additional tools and attachments for graduating scales and circles, and for working various forms and shapes.

In addition to the hand and lathe tools of the usual kinds there are tools of the greatest accuracy, consisting of standard surface-plates, straight-edges, and squares of various sizes, a standard measuring machine, measuring from zero to twelve inches by the ten-thousandth of an inch, a universal grinding machine for producing true cylindrical and conical forms, and a set of Betts's standard gauges.

In the iron and brass foundry and the blacksmith shop instruction is given in molding, casting, and forging. The cupola used is one of Colliau's improved, with a capacity of melting one ton of iron per hour.

For the purpose of instruction in experimental work there is a twenty-ton Riehle testing machine, arranged for testing the strength of materials by tension, compression, and transverse strain; Richards's and Thompson's steam-engine indicators, and Amsler's planometer; Schaeffer & Budenberg's revolution counter, steam-gauges, injector, inspirator, pop-valve, steam pump; Baldwin's link and valve motion, experimental valve motion,

together with a large collection of brass, iron, and wooden models illustrative of mechanical principles.

Closely connected with the lecture rooms in the department of mechanic arts is the school of freehand and industrial drawing, in which there is a large collection of studies of natural and conventional forms, both shaded and in outline; of geometrical models, and of papier mâché and plaster casts, including a number of antique busts, casts of parts of the human figure, studies from nature, and examples of historical ornament.

NORTH CAROLINA.

THE STATE UNIVERSITY.

The original constitution of North Carolina, adopted in 1776, provided that all useful learning should be encouraged and promoted in one or more universities.

The fortunes of war were such as to delay the founding of an institution of the contemplated character until 1789, and its doors were not opened to students until 1795.

It prospered from its first opening until another war, more desolating than that of the Revolution, called away its students, diminished its property, and impoverished its patrons.

It was in this depressed condition when the State received the land scrip which had been issued by the national government, and the university was considered the proper institution for the benefits of the fund which should arise from this grant.

The scrip was disposed of in a manner which did not escape criticism. The university, at the time of the sale of the scrip, received $10,000, which was devoted to the payment of university debts. The trustees claimed the right to do this because they furnished a large tract of land, which might be available in agricultural instruction.

Not obtaining further aid, the university was compelled to suspend operations in 1872. In 1875 the remaining proceeds of the land grant were made available, and the university was reorganized and reopened.

Its objects, so far as they have a bearing upon industries, are "to afford theoretical instruction in the sciences relating to agriculture and the industrial arts."

As there have been no funds derived from the State or other sources which can be used for the establishment of an experimental farm, the university is at present enabled only, in the words of the act of Congress of July 2, 1862, donating the land scrip, "to teach the branches of learning relating to agriculture and the mechanic arts, without excluding the classics and other scientific studies."

The endowment of the university consists of the $125,000, realized from the sale of the land scrip, the Moore scholarship fund of $5,000 in United States bonds, and the Deems fund of $12,000 to be used for loan to indigent students. The former sum is invested in a North Carolina registered certificate, which yields an annual income of $7,500.

The State has recently appropriated $5,000 per annum, so that, with tuition money, the total income is about $19,000, and the expenses of the teaching staff about $16,000, the annual saving being devoted to the extinguishment of a small floating debt incurred for building and repairs.

The number of instructors and lecturers is thirteen. They occupy the following chairs: political economy, constitutional and international law; mathematics; Greek and French; moral philosophy; history and English literature; general analytical and agricultural chemistry; Latin and German; engineering, mechanics, and astronomy; geology, physiology, zoölogy, and botany; natural philosophy; the theory and art of teaching; law; anatomy and materia medica; geology of North Carolina (special).

The persons occupying the last four positions named are not charged with duties connected with the discipline of the university.

The number of students in attendance in the year 1881–'82 was 199. Of these 140 were pursuing the regular undergraduate courses, 8 were post-graduate students, 47 were optional students, and 30 were studying a profession. Several were in more than one department and therefore counted twice in the latter enumeration.

The graduates from the reopening of the university up to and including 1882 numbered 90, of whom 55 took the degree of bachelor of arts, 23 of bachelor of philosophy, and 12 of bachelor of science. No record is kept of their occupations.

The expense for tuition is $85 per annum; but there are ninety-six State scholarships and three created by private contribution; and indigent students who are worthy of aid are admitted upon giving their notes for tuition, and in extraordinary cases entirely free. The State scholarships are filled by appointment of the boards of commissioners of the counties, and secure to the person aided free tuition and room rent.

Only males are eligible to either the scholarships or the university.

The university offers three regular courses of study: the classical, the philosophical, and the scientific. The requisites for admission to the scientific course are only English studies, such as are pursued in the common schools; for admission to the philosophical course, algebra and Latin or Greek are added; and both Latin and Greek must have been pursued by those who would enter the classical course. The amount of reading in the classics is slightly less than that required for admission to most northern colleges.

The studies of the courses are as follows:

I.—CLASSICAL COURSE.

The figures in parentheses denote the number of recitations or lectures per week.

First Year.—Algebra and geometry (5), Latin (4), Greek (4), rhetoric and history (2).

Second Year.—Trigonometry, surveying and analytical geometry (4), Latin (4), Greek (4), zoölogy, physiology, and botany (3).

Third Year.—Physics (3), chemistry (3), logic and rhetoric (2), elocution (1), and any two of the following: Calculus (3), Latin (3), French (3), German (3), natural history (3), industrial and agricultural chemistry (3), Greek (3), surveying and engineering (3).

Fourth Year.—Mechanics and astronomy (3), geology and mineralogy (3), political economy, constitutional and international law (3), English literature (3), essays and orations (1), psychology and moral philosophy (2).

II.—PHILOSOPHICAL COURSE.

First Year.—Algebra and geometry (5), Latin or Greek (4), French (3), rhetoric and history (2).

Second Year.—Trigonometry, surveying and analytical geometry (4), Latin or Greek (4), German (3), zoölogy, physiology and botany (3).

Third Year.—Physics (3), chemistry (3), logic and rhetoric (2), elocution (1), and any two of the following: Calculus (3), Latin (3), German (3), natural history (3), Greek (3), French (3), industrial and agricultural chemistry (3), surveying and engineering (3).

Fourth Year.—Mechanics and astronomy (3), geology and mineralogy (3), political economy, constitutional and international law (3), English literature (3), essays and orations (1), psychology and moral philosophy (2).

III.—SCIENTIFIC COURSE.

First Year.—Algebra and geometry (5), English (2), Latin or Greek (4), physiology, zoölogy and botany (3), natural history, laboratory (2).

Second Year.—Trigonometry and analytical geometry (4), chemistry (3), French or German (3), rhetoric and history (2), advanced botany (2), book-keeping (1).

Third Year.—Surveying and engineering, or calculus (3), industrial chemistry and qualitative analysis (5), physics (3), French or German (3), business law (1).

Fourth Year.—Mechanics and astronomy (3), geology and mineralogy (3), political economy, constitutional and international law (3), English literature (3), and any one of the following: Calculus (3), surveying and engineering (3), quantitative analysis (3), psychology and moral philosophy (2).

IV.—TEACHERS' COURSE.

This course is intended to prepare young men to be teachers, either in the public or in private schools. It embraces all the studies required by law to be mastered by public school teachers, and several others that are indispensable to excellence in teaching. Students pursuing this course may also select, free of charge, any studies embraced in the other courses. Certificates will be awarded those who complete the course. It is believed that the studies embraced in this course and in the scheme of instruction offered in the University normal school, which is taught during the summer vacations and is free to all, will be of incalculable benefit, not only to professional teachers, but to all persons intending to enter into any business or profession and unable to complete one of the regular four years' courses of study in the university.

First year.—English, reading and elocution, arithmetic, algebra, geography (physical and descriptive), physiology and school hygiene, drawing and writing, Latin or Greek, theory of teaching.

Second year.—Rhetoric, history, reading and elocution, book-keeping, surveying, algebra, geometry, natural philosophy, business law, composition, theory of teaching.

The following synopsis of the work done in chemistry, natural history, natural philosophy, and engineering, shows in greater detail the course of instruction in the departments more nearly allied to agriculture and the mechanic arts:

In the department of chemistry there are four distinct classes. A student pursuing the regular course enters in his first year class of general chemistry. In that class he learns the laws of physics so far as necessary for a clear understanding of chemistry proper, then studies the philosophy of chemistry, the metalloids, the metals, their properties and compounds, and lastly organic chemistry (which includes the compounds formed in the process of vegetable and animal life). During the second year he pursues a course of laboratory work (six hours a week throughout the year) in which the substances of which he has heard the year before are placed in his hands so that he may investigate their properties and obtain a better knowledge of them. He is taught all the methods of detecting these substances and establishing their identity, whether alone or in compounds, the so-called qualitative analysis. During the same year he attends a course of lectures on the application of chemistry to the industrial arts, learning first about the extraction of the useful metals from their ores—their valuable properties and their uses; then methods of manufacturing the most important chemicals—potash, soda, salt, sulphuric acid, ammonia, &c.; then the manufacture of glass, porcelain, and earthenware; the production of foods, sugar, wines, and nervous stimulants. The subject of clothing engages his attention next, the dyeing and bleaching of cloth, tanning of leather, &c.; then the subject of building materials, artificial stone, lime, cements, paints, and preservation of wood; and lastly the manufacture of candles, soaps, inks, matches, &c. The last portion of the course is especially devoted to the application of chemistry to agriculture, the chemical constitution of plants, soils, and the atmosphere and the nature of plant-food, application of fertilizers, &c.

In his third year the student gives his time altogether to practical laboratory work. The course can be so varied as to suit the wants or aims of each student. If he desires to fit himself as a practical analyst, he is given instruction in the methods of analysis of minerals, soils, marls, mineral waters, fertilizers, &c.; if he wishes to become a teacher he is taught how to study the properties, constitution, syntheses, and decompositions of chemical compounds; if a physician or druggist, he can devote his time more especially to poisons, adulterations, and microscopical work.

All of these courses are fully carried out at present, but it is hoped that they can be made in time even fuller and more complete. Instruction is given by means of lectures, the training gained by taking notes being looked upon as very important. At the same time good reference books are recommended for use in the various classes. In order that the facts may be more clearly impressed upon the mind, numerous experiments are made in illustration of them, and that the knowledge may not be altogether one gained from mere descriptions, the various substances, as far as possible, are shown to the students, thus helping greatly to fix their nature in the memory. For purposes of illustration a very considerable number of specimens have already been collected and the collection is being continually added to.

The attempt to increase the usefulness of the course of lectures on industrial and agricultural chemistry by the collection of industrial specimens has met with pleasing success considering the necessarily small amount of time that has been given to it so far. These specimens illustrating the various steps in manufacturing processes and the resulting products serve as no mere description could to bring the whole subject clearly before the mind of the students.

GEOLOGY, MINERALOGY, BOTANY, ZOÖLOGY, PHYSIOLOGY.

The department of natural history embraces geology and mineralogy, zoölogy and botany, and the instruction is divided into three courses corresponding to these subdivisions, as will be seen below. The instruction in the several branches is intended to be practical. In all cases the economic bearings of the sciences will be considered as a prominent feature, and especially their bearing upon agriculture. The instruction will be given by lectures and text-books combined, supplemented whenever possible by work in the laboratory and in the field.

The course in geology and mineralogy will occupy three hours per week during one year. It will include mineralogy and lithology during the first session, general geology during the first half of the second session, and economic geology during the latter half of the second session. The instruction in economic geology will be devoted mainly to a consideration of geology in its relation to agriculture and mining, and special attention will be paid to the soils, marls, ore-deposits, and other economic geological products of North Carolina.

In zoölogy, in addition to physiology and hygiene, and general zoölogy, there have been added a course of lectures, laboratory, and field work on beneficial and noxious insects, and a course of laboratory work in general zoölogy.

In the course in physiology and hygiene there will be given also a course of special lectures on school hygiene.

In botany a course of instruction will be given during the spring session in physiological botany, including a study of the plant, structure, the relation which the different parts bear to one another, and plant analysis; and an advanced course, extending through one year. The advanced course will include a study of (*a*) rusts, smuts, and other fungi parasitic upon field crops, (*b*) grasses and forage plants, and (*c*) vegetable physiology, or the growth and cultivation of plants.

NATURAL PHILOSOPHY.

The studies are:

1. Rational mechanics, including statics, dynamics of a particle, and an introduction to rigid dynamics.
2. Astronomy, including spherical and practical astronomy and cosmical physics.

The theory of central forces is studied in connection with mechanics.

PHYSICS.

This class has completed during the term the subjects of mechanics, hydrostatics, pneumatics, and heat. To test the student's thorough comprehension of the laws and facts of physics, numerous examples are given out in every branch of the subject. It is the aim to require the students to perform for themselves, as far as practicable, the experiments given in the text, and thus familiarize themselves with the principles and construction of the instruments used. The experience of those engaged in teaching this subject shows that a few hundred dollars' worth of apparatus to be thus used by the students will be productive of better results than ten thousand dollars' worth which the students are allowed to look at only.

SURVEYING AND ENGINEERING.

The first portion of this course is devoted to mechanical drawing. The student is taught first the principles of projections and shades and shadows; later he is required to execute working drawings of details used in wood, metal, and stone constructions, and also drawings of ordinary structures and machines. In the surveying proper, field practice is made the prominent feature, each student having abundant opportunity to use the instruments himself. Field practice extending nearly over the entire year is afforded in (1) *Surveying:* measuring land, dividing up land, laying off land of given shape and area, surveying roads and streams, and making accurate maps and plots from actual surveys; (2) *Engineering*, which includes leveling, with its application to making roads and ditches, laying out curves of any curvature on the ground, setting slope-stakes, the measurement and calculation of earth-work, and all the work of locating a railroad up to the point of actual construction.

Instruction is also given in the principles involved in and the drawings required of the best and simplest kinds of roofs and bridges.

While the instruments used generally in this work are of the best make and costly, methods are exhibited, when possible, by which many of the above operations can be carried on with simple instruments which can be made by any person possessing ordinary mechanical skill.*

BOOKKEEPING.

The subjects of single entry and double entry are thoroughly explained and illustrated.

Each student is required to write several sets, including, besides the principal books, various auxiliary books and business papers.

An effort is made to present the science in as simple and practical a form as possible, so that each one at any time may readily apply it to his own affairs.

AGRICULTURAL STUDIES.

By availing themselves of an optional course, students whose time and means are limited may obtain purely agricultural instruction in branches deemed of special value.

The appliances for instruction and illustration consist of apparatus, not of large amount at present, but of most improved make and being augmented every year, the contents of several museums, laboratories for chemical, mineralogical, zoölogical, and botanical work.

The museums contain geological, mineralogical, zoölogical, botanical, industrial, and

* A considerable amount of excellent apparatus has been recently purchased in Germany for the use of the department of physics.

chemical specimens; and a room has been devoted to the accommodation of valuable agricultural tools, machines, and implements.

The laboratories are supplied with appliances necessary for the prosecution of the work intended to be done in them, according to approved modern methods.

The university buildings are eight in number. They are of brick and can accommodate 500 students. One is five stories in height; another, four; three are three stories; two, one story; and one, one story with basement. The lecture and recitation rooms are large and commodious.

The information presented in this statement of the condition and work of the University of North Carolina has been chiefly supplied by the courtesy of its president, Hon. Kemp P. Battle. He has also outlined the practical work of the university in letters subsequent to the one which has been used in the preparation of this article. From them the following extracts are selected:

The instruction in this institution is confined at present to theoretical teaching in our lecture room, and to practical and field work in chemistry, botany, zoölogy, mineralogy, engineering, physics, &c., as explained above. It is expected at no distant day to conduct open air experiments in agriculture as ancillary to theoretical instruction, and we are ready to conduct field experiments on a larger scale for the benefit of the public, as soon as the means shall be placed at our disposal. Until last year (1881), the "State Agricultural Experiment and Fertilizer Control Station" was located in the university buildings, its establishment by the State and its very successful beginnings and working for several years being largely owing to the exertions and counsel of the officers of the university. Its publications in the press of the State and in books and pamphlet form have very greatly enlightened the people of the State in agricultural chemistry.

The influence of the station has been very great on the purchase and manufacture of fertilizers. It has driven inferior brands from the market, increased the quality and decreased the price of the brands now remaining, and has disseminated a vast deal of information among our people on the subject of fertilizers; so that they buy more commercial manures than ever before, and at the same time engage more extensively in the preparation of fertilizers on their own farms.

By thus creating an intelligent demand for fertilizers, the station has greatly increased the annual products of the soil, and there is reason to believe that its good effects will be lasting and will gather strength year by year.

The station has also driven fraudulent seedsmen out of the market by its tests for the purity and power of the seeds here offered for sale.

It has also given much attention to the analysis of mineral waters, and its influence in regard to the purification of water, both on the farm and in the cities, has been exerted constantly and beneficially. Specimens of marl have frequently been analyzed, and the production of marl for manure has been economized.

The scientific instruction given in the university relates to the following sciences: chemistry (general and applied), agricultural chemistry, physics, civil engineering, botany, zoölogy, physiology, geology, mineralogy.

No trades or industries are taught, but in an agricultural community like ours it is of the first importance that the foundation be laid for scientific observation through life.

Habits of attention, observation, analysis, and generalization of scientific phenomena are impressed upon our students early in life; and these, fortified by an exact and intelligent acquaintance with the general principles of the sciences, cannot fail to produce more useful citizens and more productive workmen.

The structure, habits, and diseases of animals, the uses, growth, and nature of plants, the various sorts of food and their special uses, the value of minerals and their distinguishing features, and the various applications of the forces of nature to the service of man, are among the subjects that are presented to our students during their period of study.

The university had been in a state of suspension for several years, when it was reopened in 1875, in consequence of the restoration of the land-grant fund by the State.

Its revival has been the beginning of a new life in the education of the State.

Its normal school has had an attendance during its six sessions of nearly two thousand teachers, and the courses of instruction and methods of teaching have been greatly improved, while the attendance on the schools has much increased.

Several hundred more North Carolina boys are now students in our colleges than were before. By the aid of the land grant the university began its new career.

OHIO.

STATE UNIVERSITY, COLUMBUS.

[Statements from circulars and reports.]

The chief object of the Ohio State University is to promote the liberal and practical education of the industrial classes within the State in their several callings and pursuits.

The subjects commonly included among college studies are taught, and special provision has been made for extensive and practical instruction in the various branches of natural science and their applications.

The leading industries of the State—agriculture, mechanics, mining, and engineering—have each a separate department and special course of study, and the sciences which underlie these industries also have special departments, and are taught theoretically and practically by eminent instructors, who have ample means for illustration and for practical work at hand.

UNIVERSITY FINANCES.

The grounds, buildings, and apparatus of the university are valued at $500,000, and its endowment fund amounts to $559,628. The sources from which the latter was mainly derived were the proceeds of the national grant of 630,000 acres of public land and the net proceeds of certain tracts known as the Virginia military lands. The proceeds of the national grant were $342,450. This sum was put at interest and the interest added to the principal until the fund amounted to a little more than $500,000.

The sum realized from the sale of Virginia military lands up to the time of making the report for 1880 was $39,031.49. A gift of $300,000 from Franklin County, in which it is located, and frequent appropriations from the State treasury (among which the proceeds of the Virginia military lands are included) have done much to swell the property of the university to its present amount.

The special appropriation for 1880 amounted to only $3,350, of which $1,500 were for farm improvements and stock.

The cash receipts of the university for 1880 from the permanent endowment fund were $27,866; from incidental fees, $3,798; from State appropriation, $6,701; from military lands, $7,285; from miscellaneous sources, $987; cash on hand at the beginning of the year, $4,987; total cash receipts, $51,624.

The disbursements for the same period amounted to $48,526, of which $26,461 were paid for salaries.

FACULTY, STUDENTS, AND GRADUATES.

The faculty are 16 in number. Of these 12 are professors, including the president; 1 is an officer of the United States Army, on duty as commandant of the university cadets and professor of military science and tactics; 1 is an officer of the United States Navy, on duty as professor of steam engineering; 1 is assistant professor of industrial art, and 1 is instructor in French and German languages.

The professorships are of philosophy and political economy, geology, general and applied chemistry, agriculture and veterinary science, mathematics and civil engineering, zoölogy and comparative anatomy, mechanics, physics, mining and metallurgy, history and English language and literature, Latin and Greek, horticulture and botany. These 12 professorships are here named in the order of appointments of the present incumbents, with the exception of the first chair, which is occupied by the president.

In addition to the professors and assistant professors a number of tutors are employed in primary work.

The number of students increased from 27 in 1873 to 330 in 1882.

No tuition fees are required, but an incidental fee of $15 per annum is charged; and advanced students in chemistry are required to pay $10 a term for materials consumed in laboratory work and the deterioration of instruments. Students in physics pay $7 per term laboratory fees.

The first graduates reported to this bureau were those of 1878. The class of that year numbered 6 and all but 1 took the degree in science.

The graduating class of 1879 had 7 members, and one post-graduate degree was given in course, that of Ph. D.

The class of 1880 had 9 members; 6 of them received the degree of bachelor of arts, and 1 each bachelor of science, mining engineer, and mechanical engineer.

The class of 1881 had 9 members; 2 of them received the degree of bachelor of arts,

5 the degree of bachelor of science, 1 the degree of bachelor of philosophy, and 1 the degree of mining engineer. There was conferred also one post-graduate degree (of mining engineer) upon a bachelor of science.

The other degrees given by the university are bachelor of philosophy, bachelor of agriculture, and civil engineer. Certificates of work done are also granted.

There are seven courses of study preparatory to the seven degrees which have been mentioned. Three of them are general and four technical.

The general courses are in arts, philosophy, and science. The technical courses are in civil engineering, mechanical engineering, mining engineering, and agriculture.

Of the general courses that in science alone has a special industrial bearing. Its studies may be outlined as follows:

Freshman year: Analytical geometry, differential and integral calculus, chemistry, mineralogy, freehand drawing, and French.

Sophomore year: Botany, zoölogy, French, and an elective course in botany, chemistry, or physics, continuing through the year.

Junior year: Geology, astronomy, and two elective courses in the sciences above mentioned with the addition of vertebrate anatomy and physiology.

Senior year: Rhetoric and logic, and two elective courses in sciences, or one in psychology and ethics and the other in science.

The three engineering courses agree with the course in science for the freshman year, and are similar to each other in all but the special studies during the remaining three years.

The course in civil engineering has roads, drawing, geodesy, and civil engineering for special studies; the course in mining has an extended course in geology and chemistry, and furnishes thorough instruction in metallurgy, mineralogy, assaying, the treatment of ores, the theory of veins, mining engineering, and the construction of metallurgical works; the course in mechanical engineering gives prominence to physics and drawing, and is especially arranged for the purpose of giving instruction in thermo-dynamics, prime movers, mill work, and mechanism, with practice in the mechanical laboratory.

The course in agriculture differs from all the others. Its freshman year is devoted to work in the mechanical laboratory and the study of chemistry, mineralogy, surveying, civil engineering, and the construction of roads, drains, &c. The next year is wholly taken up with botany, zoölogy, and veterinary anatomy.

The special agricultural studies, commencing in the junior year, include a discussion of soils, manures, crops, and tillage, and farm improvement and management. The other branches pursued are geology and physiology.

In the senior year rhetoric and logic are the general studies; and the special studies include domestic animals, stock breeding and feeding, dairy products, and the diseases of animals and their treatment.

The practice of electing courses of study is so common to the students and so much encouraged by the university that an account of the institution would not be complete which did not give a view of the departments of instruction from which selection may be made and the character of the work done in them, so far as it has relation to industrial education.

The departments are fourteen in number, viz: Physics, chemistry, zoölogy and comparative anatomy, geology, agriculture, botany, mathematics, civil engineering, mechanical engineering, mining engineering, military science and tactics, modern languages and English, Latin and Greek, and history and philosophy. Of the last three departments no further mention is necessary.

In physics there are elementary and advanced courses. The latter occupies two years, and includes the application of graphics and mathematics to physics, lectures on the use of instruments and the details of observation and experimental work. The laboratory is supplied with expensive and well selected apparatus designed for illustration and for the purposes of original research.

Chemistry is required to be studied two terms and a half by all who are candidates for a degree. In this time organic and inorganic chemistry and the relation of chemistry to the arts are considered, and the student is prepared for the advanced course, which covers two years, and is required of students in civil and mining engineering. The work in qualitative analysis is supplemented by instruction in the use of the spectroscope and the blow-pipe. The volumetric and gravimetric methods of quantitative analysis are both taught; and after known compounds have been sufficiently investigated, assistance is given in doing work with substances which are employed in agriculture, medicine, pharmacy, or the arts. A full course in assaying, given in the mining laboratory, is open to students in chemistry.

The State has recently appropriated $20,000 for the erection of a new building for the chemical and mining laboratories. This building is now in process of erection, and will be completed before the beginning of the winter term. It is 160 feet long in front and

80 feet deep in the central portion. It will be two stories high, with basement and gable roofs. The upper floor will be devoted to the chemical department exclusively. The first floor will be occupied by the mining department. Ample space on this floor is reserved for agricultural chemistry.

In the department of zoölogy and comparative anatomy instruction in human anatomy and physiology is given to preparatory students; in zoölogy to the sophomores of all the courses, and in more special studies to junior and senior students at their election.

The object of the sophomore year course in zoölogy is to afford a general understanding of the animal kingdom as a whole, to illustrate the objects and methods of classification, to indicate the more important morphological relations on which classification is based, and to give an insight into the principles which underlie the phenomena of animal life.

The elective work of the junior year is in connection with comparative anatomy, and consists largely of practice in the laboratory and the dissecting room of the department. It may be so modified as to prepare the student for the advanced study, in the senior year, of either paleontology or physiology and histology.

Students in agriculture pursue the advanced studies in this department one year earlier than students in science, that is, during their sophomore and junior years; and special students take up such studies as they may be desirous of pursuing and are prepared to undertake.

The collections and appliances of the department have been carefully selected.

The laboratory is supplied with microscopes and other appliances for biological work; and the dissecting room affords ample facilities for performing the work incident to the study of veterinary and other branches of anatomy.

The department of geology presents no marked features. The collections made by the State geological survey are in the possession of the university, and valuable fossils and minerals have been added from various sources. Every geological formation in the State is represented in the collection.

In the department of agriculture work is provided for three years. The first and second terms of the first year's work are applied to the examination of soils, their origin, composition, organic relations, adaptations to particular crops and methods of culture, and the preservation and restoration of fertility; and to learning the character and value of forage plants, the approved methods of field culture, and the value and application of fertilizers.

The latter part of the year is devoted to the study of farm work and improvements. Under the latter head come drainage, irrigation, the construction and repair of roads and fences, and the erection of buildings. The second year is mainly spent on the following topics: the natural history, description, and adaptation of the various domestic animals; horse-training, cattle-feeding, wool-growing, dairy management, etc. The work of the third year is spent on veterinary science.

The State has established an agricultural experiment station, which is now located at the university. The station is sustained by appropriations from the State.

The experiments and investigations will be carried on both in the field and laboratory, and will deal with the following great agricultural interests, viz: (1) Grain raising. (2) Stock farming and dairy husbandry. (3) Fruit and vegetable culture. (4) Forestry.

The station is prepared to test varieties; to analyze and test fertilizers and manures; to examine seeds that are suspected of being unsound or adulterated; to identify and name weeds and other plants; to investigate, and describe when known, the habits of injurious and beneficial insects; and other work of a similar character that properly comes within its province.

Horticulture and botany have been provided for by the establishment of a separate professorship, the aim of which is to unite scientific knowledge and investigation with the most skillful practice in the important pursuits of fruit growing, gardening, forest culture, and other like divisions. The professor of horticulture and botany is the director of the agricultural experiment station.

An herbarium, representing quite completely the flora of the State, is accessible to students.

Mathematics are taught by two professors. One term is given to astronomy, and appliances for the use of students in this subject are being obtained.

Civil engineering has a prominent place, and the course in it includes practical surveying, the location and construction of railroads and bridges, strength of materials, geodesy, and studies of a more technical character. Varied and adequate field work is undertaken, for which a full set of finely-constructed instruments has been provided.

The department of mechanical engineering has recently been equipped, and is attracting many students.

The course of study includes the principles of mechanism, machine-drawing and de-

signing, four terms of laboratory work, and the consideration of auxiliary branches. It is explained in a recent report as follows:

"In the principles of mechanism are studied the parts of machinery by pairs, or elementary combinations of mechanism. In this the form and arrangement of the parts necessary for securing the desired modification of motion are sought.

In the machine-designing the student takes up some problem in the shape of a particular machine for a special purpose. The forms, dimensions, and arrangements of the parts are decided upon, and then a drawing is carefully made of the whole. Detail drawings to regulation size are then made, and finished in shade lines, as done in the best shops. The quality of these drawings is sufficient for the requirements of photo-engraving for illustrations upon circulars.

In thermo-dynamics are studied the principles which form the groundwork of all heat-engines. In prime movers are studied all kinds of heat-engines, such as steam, hot-air, &c., and also wind and water wheels. Mill work and machinery takes up valve-gears, fly-wheels, governors, efficiency of parts of machines, strength of parts, &c.

The mechanical laboratory is intended for acquainting the student with the materials used in machine construction; with the forms customary in machinery; to impart a degree of skill in the use of tools and a knowledge of the operations and practices of the shop.

The first term consists of the actual use of tools in executing a set of forms chosen with a view to supplying the greatest possible amount of practical instruction for the time. This is combined with weekly lectures on tools and their use.

The second term carries the above practice to the fitting together of parts and to the use of machine tools, such as the lathe, planer, etc. This is combined with weekly exercises in designing and drawing of machine elements, such as cranks, bearing-boxes, stub-ends, etc.

The third term is fully occupied in fitting parts carefully together, as in the joints of machinery, and in finishing the surfaces by scraping, polishing, burnishing, etc. This is in combination with a weekly exercise in the invention of simple machines for specific operations, such as bending wire staples, cutting wool combs, &c.

The fourth term of mechanical laboratory practice is constructive. It is taken in connection with the principles of mechanism. In the latter, problems in mechanism are worked out, forms and dimensions assigned to the parts, and then these are executed in the laboratory, resulting in models of mechanical movements for the cabinet.

The course in mining engineering secures to the student careful instruction in mining, the preparation of the ore, and its metallurgical treatment.

Lectures, the study of text-books, preparation of maps and drawings, visits to existing works, and practice in estimates and designs form parts of the field of instruction. There is a collection of minerals such as are commonly met with in mining operations, a full equipment of furnaces and ores for assaying, and models exhibiting all the common forms of crystals.

The aid which the university directly renders to the agriculture of the State is given through the lectures on practical agriculture and the experiments conducted upon the farm. The lectures are given in the early part of each year, and are attended by intelligent farmers, who wish to obtain modern and correct scientific ideas of subjects related to their occupation.

The professor of agriculture not only contributes to this course of lectures (if he does not furnish the whole of it), but also attends the county institutes for farmers.

The university farm contains 320 acres of land. Valuable experiments are constantly being tried upon it. Those reported in 1880 were in wheat culture (including yield of varieties, effects of early and late sowing, late plowing, &c.,), corn culture, potatoes (yield, effect of fertilizers, etc.), forage crops, millet, rye, rice, corn, grasses, and clover; thorough drainage, and sorghum culture.

A circular of information on the classification of students, issued in June, 1882, is as follows:

CLASSIFICATION OF STUDENTS.

The attention of students is called to the following system of classification, which has recently been adopted by the faculty for the purpose of doing away with a large amount of unnecessary irregularity. There is no desire or intention on the part of the faculty to depart from its former liberal policy toward students seeking special facilities in any particular direction *for a definite purpose;* such students will, however, be in future required to state the ends which they have in view, and to pursue such studies as are, in the judgment of the faculty, conducive to the end designated. On the other hand, the faculty cannot escape the conviction that there is a great deal of purposeless irregularity, the result of mere whim or fancy in some instances, which they regard not only as det-

rimental to the progress of the institution but also to the welfare of the students themselves. It is this conviction which has led to the adoption of the plan herein described:

First. The various departments of the university will hereafter be classified in four schools, designated as follows:

The school of arts and philosophy, including those studies which enter into the courses leading to the degrees of bachelor of arts and bachelor of philosophy.

The school of science, including those studies which enter into the course leading to the degree of bachelor of science.

The school of engineering, including those studies which enter into the courses leading to the degrees of civil engineer, mechanical engineer, and mining engineer.

The school of agriculture, including those studies which enter into the course leading to the degree of bachelor of agriculture.

Second. Every student (resident graduates alone excepted) shall enter one of the above schools or shall be assigned to that one in which the majority of his studies are found (in case of irregularity). There shall be no unclassified students.

Third. Each school will be under the direction of a standing committee of the faculty, having power to act in all matters pertaining to the studies of students in such school and in matters of minor discipline. The following committees have been appointed for the various schools:

Arts and philosophy.—The president, the professors of Latin and Greek, history, geology, chemistry, and French and German.

Science.—The president, the professors of mathematics, chemistry, physics, geology, and zoölogy.

Engineering.—The president, the professors of civil engineering, mechanical engineering, mining engineering, physics, and drawing.

Agriculture.—The president, the professors of agriculture, horticulture. mechanics, metallurgy, and zoölogy.

Students will report at the beginning of the fall term to the secretaries of their respective committees, whose names will be announced at that time.

Fourth. All students in each school will be regarded as belonging to one of two groups; first, those whose purpose it is to enter upon one of the regular courses of study, with the expectation of taking its degree; second, those who come to the university for the purpose of pursuing some special study or line of work, and who do not expect to take a degree.

The courses of study leading to the various degrees having been arranged by the faculty in the order which they believe to be the best adapted to the general requirements of students, *all who do not belong to the second of the groups indicated* will be required to enter upon the regular work of the college classes to which they belong, or in case of present irregularity to remove such irregularity as speedily as practicable in the manner prescribed by the committee of the school in which they are classed, and no such student will be allowed to take more or other than his regular studies without presenting a request with reason therefor to his committee and receiving its consent. Such consent may be revoked at any time when it may seem advisable to do so.

Students belonging to the second group, viz: those coming to the university for a limited time with the definite purpose of pursuing some special line of work, will in each case enter the school in which their proposed work is chiefly included, and shall lay before the committee a statement of the end in view, the studies proposed for the accomplishment of that end, and the probable period of residence.

While it will be the purpose of each committee, in accordance with the well-established policy of the university, to allow to such students full freedom in the selection of the branches which they desire to pursue, subject only to the necessary limitations that they are prepared to take up the branches they select and that such branches are in accordance with the end proposed, it is also their intention to hold students as regularly to the performance of their accepted schemes of work as they do the members of the first group to their prescribed course of study; and they will refuse admission to this group to all of whose definiteness of purpose or fitness to undertake the work proposed they fail to receive satisfactory evidence.

OREGON.

CORVALLIS COLLEGE.

The legislature of Oregon accepted the national grant in behalf of agricultural education October 9, 1862. Nearly ten years later it gave the benefit of the grant to Corvallis College, at Corvallis, an institution established in 1865 and chartered in 1868 for the purpose of the preparatory and collegiate education of the youth of Oregon. The general

character of the college has been maintained, although agricultural instruction is afforded. The object of this instruction is to give students a thorough knowledge of scientific and practical agriculture, and through them so improve the present system of crop culture that there shall be a minimum exhaustion of the soil and yet maximum crops.

The grant with which Corvallis College was endowed amounted to 90,000 acres. Part of this land has been sold for $50,000. The grounds, buildings, and apparatus are valued at $10,000. The annual income is about $6,000.

The faculty consists of the president, who is professor of moral philosophy and physics, professors of mathematics and languages, and teachers in the preparatory department and of drawing and painting. The subjects of instruction are arranged by schools. No regular courses of study are given in the catalogue. Agricultural studies treat of the composition and analysis of soils, the preparation of soils and manures, modes of drainage, construction of farm buildings, and stock raising. General, analytical, and agricultural chemistry are taught by the president; mineralogy, geology, and zoölogy, by the professor of mathematics; and botany and fruit culture, by the professor of languages.

The number of students enrolled in 1881–'82 was 150, of whom 90 were males and 60 females. Tuition for the scholastic year is, in the primary classes, $18; preparatory department, from $30 to $36; in the scientific and agricultural courses, $39; and in the classical college, $45. There are sixty free scholarships for young men over sixteen years of age. They are secured by application to the State senators or the president of the college.

The graduates of the college up to and including 1881 numbered 47, 35 males and 12 females. The men received degrees as follows: A. M., 3; A. B., 3; B. S., 29; the women, with one exception, took the degree of B. S. Farming is the favorite occupation among them. About five hundred young men, mostly farmers' sons, have received an education at the college.

PENNSYLVANIA.

PENNSYLVANIA STATE COLLEGE, CENTRE CO.

[Statement from catalogue, &c.]

The leading object of the Pennsylvania State College is, "without excluding other classical and scientific studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislature of the State may prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."

Since its opening in 1859 the college has sought to teach the various sciences in such a manner as to show their relations to the more common industries, and thus to combine the theory with the practice, the science with the art. The entire organization and equipment have, therefore, had these objects in view.

ENDOWMENT, ETC.

The income of the college is almost wholly obtained from a bond of the State of Pennsylvania for $500,000, upon which interest is paid semi-annually at the rate of 6 per cent. per annum. The property of the institution—its buildings, farm, farm stock, apparatus, &c.—is valued at $532,000. This property was in 1866 mortgaged for $80,000. For the payment of the mortgage provision was made by act of the legislature approved June 12, 1878. Owing to the expenditure during 1879 of $10,000 for steam heating apparatus, $2,000 for the extension and improvement of laboratories, and $5,000 for a professor's house, the floating debt was increased to $33,000; but that is now in process of extinguishment by regular additions to a sinking fund. The amount expended for instruction in 1882 was $17,500.

FACULTY AND STUDENTS.

The faculty consists of the president, who is professor of political and social science, and professors of English literature and ancient languages, botany and horticulture, agriculture and agricultural chemistry, mathematics and astronomy, military science and tactics, chemistry, modern languages, physics, civil engineering, geology and zoölogy, an assistant professor of ancient languages, and a lady principal in charge of the female department. There are also three other teachers in the preparatory department and an instructor of music.

There are superintendents of the college and experimental farms, the eastern experimental farm in Chester County, and the western experimental farm in Indiana County.

The students in attendance in 1880–'81 were classified as follows: Resident graduates, 5; graduates at last commencement, 3; seniors, 10; juniors, 9; sophomores, 10; freshmen, 18; special students, 8; preparatory, 85; males, 125; females, 23; total, 148.

Tuition is free. Incidentals, including room rent and all college charges except chemicals, are $40 per annum.

The whole number of graduates up to and including 1882 was 122. Of these 52 received the degree of bachelor of science, 46 of bachelor of agriculture, and 24 of bachelor of arts. Their occupations, as far as known, are lawyers and law students, 18; farmers, 18; teachers, 15; physicians and druggists, 11; chemists, 10; engineers (mining or civil), 6; manufacturers, 6; deceased, 5; miscellaneous, 33; total, 122.

COURSES OF STUDY.

The act of Congress of July 2, 1862, which the college regards as of binding authority, requires instruction to be given in a large number of subjects. In order to employ fully the large teaching force demanded, to meet as far as possible the wishes of its patrons, and to serve to the best advantage the interests of the State, the college has organized and offers to both sexes the following courses of instruction:

Preparatory course, classical and scientific; two general courses, general science and classics; and four technical courses, agriculture, natural history, chemistry and physics, and civil engineering. It also admits special students who do not intend to take all of any college course. It still further offers to farmers and others who cannot become students a farmers' institute or course of lectures, lasting two weeks in midwinter. Particulars concerning the studies are given below.

ADMISSION.

The college admits both sexes, on the following conditions:

First. Candidates for the preparatory department must be at least 14 years of age and have a fair knowledge of the ordinary common school branches.

Second. For admission to the freshman class, general science course, the candidate must be at least 15 years of age, and pass a further examination in United States history, Olney's Higher Algebra (to quadratics), Olney's Geometry (to section 7), Steele's Fourteen Weeks in Physics, and Houston's Physical Geography, or their equivalents. For the classical course the applicant will be examined in Cæsar, Cicero's orations, and Xenophon's Anabasis, instead of physics and physical geography. Candidates for either course should have some practical knowledge of drawing and bookkeeping. Students whose advanced knowledge of some subjects will enable them to make up their deficiencies in others may be admitted conditionally. Equivalents are accepted in all cases from candidates for admission.

PREPARATORY COURSES.

As many students come from districts where there are no advanced schools, it has been found needful to maintain a department which shall prepare such persons for admission to college, and shall, at the same time, give a good practical training to those who are unable from any cause to prolong their studies beyond the ordinary academic course.

Applicants should, as stated, be at least 14 years of age and have a good knowledge of the common English branches. Preparatory students, except those who are under the immediate care of their parents and guardians, are required to room in the building, where they are under the supervision of the principal of the department and his assistants during study hours; and every effort is made to incite in them a love of study and to create and confirm habits favorable to it.

As there are two general courses in the college, there are two preliminary courses, designed to prepare for these respectively. While these have much in common, clearness demands that they be given separately. They are as follows:

IN GENERAL SCIENCE.

First year.

Fall session.—Arithmetic, algebra, physiology, English analysis.

Winter session.—Algebra, English composition, physical geography, zoölogy.

Spring session.—Algebra, English history, botany, English composition.

IN CLASSICS.

First year.

Fall session.—Arithmetic, algebra, physiology, Latin grammar and reader.

Winter session.—Algebra, English composition, physical geography, Latin reader.

Spring session.—Algebra, English history, botany, Cæsar and Latin composition.

IN GENERAL SCIENCE.

Second year.

Fall session.—Algebra, English history, natural philosophy, German. Practicum, drawing one hour daily.

Winter session.—Algebra, geometry, United States history, physics or Latin. Practicum, bookkeeping one hour daily.

Spring session.—Geometry, United States history, geology or Latin. Practicum, drawing one hour daily.

IN CLASSICS.

Second year.

Fall session.—Algebra, English history, Cæsar and Latin composition, Greek grammar and reader. Practicum, drawing one hour daily.

Winter session.—Algebra, United States history, Cicero's orations, Greek grammar and reader. Practicum, bookkeeping one hour daily.

Spring session.—Geometry, United States history, Ovid, Xenophon's Anabasis. Practicum, drawing one hour daily.

GENERAL COLLEGE COURSES.

The college offers, as already stated, two full courses, each of four years. That in general science embraces German and French, mathematics, and a fair outline of the natural and the metaphysical sciences. The classical combines with the essentials of the old time-honored "college course" a large amount of the scientific knowledge and the practical training which that course formerly lacked. Each course as here taught aims at the full development of the student's powers of observation and of reasoning.

At the close of the sophomore year the student in either course may enter one of the technical courses.

In the following schedules of studies a figure placed after any subject indicates the number of hours of recitation or of practice given to that study each week.

General science course.

FRESHMAN CLASS.

Fall Session.—Algebra (3), geometry (3), German (5), tactics (4). Practicum—drawing (4), horticulture (4).

Winter Session.—Algebra (4), geometry (2), rhetoric (4), German (5). Practicum—drawing (2), mechanic arts (6).

Spring Session.—Trigonometry (5), physiology (4), German (3), French (3). Practicum—drawing (4), horticulture (4).

SOPHOMORE CLASS.

Fall Session.—Trigonometry and surveying (4), chemistry (4), German (3), French (4). Practicum—surveying (6), chemistry (4).

Winter Session.—General geometry (4), chemistry (4), German (3), French (4). Practicum—chemistry (8), mechanic arts (2).

Spring Session.—Chemistry (3), descriptive botany (4), German (2), French (3), general geometry (4).* Practicum—chemistry (6), botany (4.)

Classical course.

FRESHMAN CLASS.

Fall Session.—Algebra (3), geometry (3), Virgil (5), Xenophon's Anabasis and Greek composition (4). Practicum—drawing (4), horticulture (4).

Winter Session.—Algebra (4), geometry (2), rhetoric (4), Virgil (3), Plato's Apology and Greek composition (3). Practicum—drawing (2), mechanic arts (6).

Spring Session.—Trigonometry (5), physiology (4), Sallust (3), Plato's Phædo (3). Practicum—drawing (4), horticulture (4.)

SOPHOMORE CLASS.

Fall Session.—Trigonometry and surveying (4), chemistry (4), Horace (3), Herodotus (4). Practicum—surveying (6), chemistry (4).

Winter Session.—General geometry (4), chemistry (4), Cicero de Officiis (3), Homer (4). Practicum—chemistry (8), mechanic arts (2).

Spring Session.—Chemistry (3), descriptive botany (4), Tacitus (4), Euripides' Alcestis (4). Practicum—chemistry (6), botany (4).

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*For the general geometry of this session students preparing for the course in agriculture or that in natural history may substitute seven hours of practicum in chemistry.

General science course.

JUNIOR CLASS.

Fall Session.—Rational mechanics (4), chemistry (3), logic (3), animal physiology (4), or differential calculus (3), (elective). Practicum—mechanics (4), botany (4), physiology (4).

Winter Session.—Physics (4), chemistry (4), zoölogy (4), integral calculus (2), or natural theology (3) (elective). Practicum—physics (3), zoölogy (4), botany (4).

Spring Session.—Physics (4), mineralogy (3), civil government (3), English literature (5). Practicum—physics (3).

SENIOR CLASS.

Fall Session.—Physics (4), geology (4), mental philosophy (3), history of ancient philosophy (3), English literature (3). Practicum—physics (4), geology (3).

Winter Session.—Geology (3), political economy (3), astronomy (4), history of civilization (4). Practicum—geology (5).

Spring Session.—Geology (3), astronomy (3), ethics (3), history of English literature (3). Practicum—geology (5), thesis or oration.

Classical course.

JUNIOR CLASS.

Fall Session.—Rational mechanics (4), logic (3), Thucydides (4), botany (4), or differential calculus (3) (elective). Practicum—mechanics (4), botany (4), physiology (4).

Winter Session.—Physics (4), zoölogy (4), natural theology (3), Greek history and antiquities (3), Demosthenes (3). Practicum—physics (3), zoölogy (4).

Spring Session.—Mineralogy (3), civil government (3), English literature (5), Roman history and antiquities (3), Sophocles (3). Practicum—physics (3).

SENIOR CLASS.

Fall Session.—Geology (3), mental philosophy (3), history of ancient philosophy (3), English literature (3). Practicum—geology (3).

Winter Session.—Geology (3), political economy (3), astronomy (4), history of civilization (4). Practicum—geology (5).

Spring Session.—Astronomy (3), ethics (3), history of English literature (3), evidences of Christianity (3). Practicum—geology (5).

TECHNICAL COLLEGE COURSES.

The technical courses now offered by the college are four in number: Agriculture, natural history, chemistry and physics, and civil engineering. For admission to either of these courses with a view to graduation, the applicant must pass an examination on the studies of the freshman and sophomore classes of one of the general courses, or their full equivalent.

1. COURSE IN AGRICULTURE.—Agriculture involves the application of the sciences to a greater extent than any other human employment. The aim, then, of the college course of instruction in agriculture is to teach how the sciences are applied to the business of farming, to afford a thorough and comprehensive knowledge of its principles and methods. It explains the nature of soils and of manures, the reasons for and the best methods of tillage, the constituents and characteristics of plants and animals, and the conditions favorable to their development; and it combines theory and practice wherever the processes involve skilled labor, but it does not consume the student's time in the mere manual labor of plowing, planting, and feeding. For instruction in this branch there are the college farms of 400 acres, with nearly 20 acres of orchard, vineyard of about 500 vines, experimental grounds of more than 30 acres, barns, implements, &c.; the libraries, the laboratories of all the different departments, each of which is in certain respects subsidiary to agriculture; and the laboratory for agricultural work, with its special appliances for quantitative analysis of grain, grasses, fertilizers, &c.

In addition to purely technical studies, the schedule includes a few others, such as mental philosophy, political economy, ethics, &c., which are needful to fit the student for the right discharge of his duties as a citizen.

2. COURSE IN NATURAL HISTORY.—The design of this course is to give a practical knowledge of geology, zoölogy, botany, &c., and to train its graduates for the work of collecting and classifying objects in natural history, and for the superintendence of scientific explorations and investigations.

Instruction is derived not only from the text books and lectures and the work in the laboratories, but from the study of the various collections and from excursions in the vicinity of the college, the surrounding district being especially rich in material illustrative of geology and botany.

3. COURSE IN CHEMISTRY AND PHYSICS.—This course aims to prepare the student for work as a physicist or a practical chemist or pharmacist; it also seeks to fit him to enter the ranks of original investigators and discoverers.

The extensive and well-equipped laboratories afford opportunities for qualitative and

quantitative work in both chemistry and physics; they enable the physicist to verify the laws of physical force, the assayist to determine the value of ores, and the agriculturist to ascertain the composition of his organic products.

4. COURSE IN CIVIL ENGINEERING.—This course was established at the opening of the collegiate year, 1881–'82. In general terms, its object is to combine thorough practical instruction and the higher mathematical training so essential to the success of the professional engineer; and to this end students are required, in addition to the ordinary class room work, to spend an unusual amount of time in the field and in the construction and drawing rooms.

SCHEDULES OF TECHNICAL COURSES.

1.—*Agriculture.*

JUNIOR CLASS.

Fall Session.—Rational mechanics (4), agricultural chemistry (3), cryptogamic botany (4), animal physiology (4). Practicum—Physics (4), chemistry (6).

Winter Session.—Physics (4), agricultural chemistry (4), zoölogy (4), agricultural engineering (3). Practicum—Zoölogy or physics, chemistry.

Spring Session.—Mineralogy (3), civil government (3), entomology (4), fertilizers (4), crops (1). Practicum—Agriculture, entomology.

SENIOR CLASS.

Fall Session.—Anatomy and breeding (4), Geology (3), mental philosophy (3), horticulture (3), crops (2). Practicum—Agriculture, dissection.

Winter Session.—Geology (3), political economy (3), feeding (4), veterinary (4), farm economy (1). Practicum—Agriculture.

Spring Session.—Dairy (3), sheep husbandry (1), ethics (3), history of English literature (3), history of agriculture (1). Practicum—Agriculture, geology, thesis.

2.—*Natural history.*

JUNIOR CLASS.

Fall Session.—Rational mechanics (4), cryptogamic botany (4), animal physiology (4), logic (3). Practicum—Mechanics (4), botany (4), physiology (4).

Winter Session.—Physics (4), zoölogy (4), phænogamic botany (4), natural theology (3). Practicum—Physics (3), zoölogy (4), botany (4).

Spring Session.—Physics (4), mineralogy (3), civil government (3), entomology (4). Practicum—Physics (3), entomology (9).

SENIOR CLASS.

Fall Session.—Anatomy and breeding (4), geology (3), mental philosophy (3), zoölogy (5). Practicum—Geology (3), zoölogy (8).

Winter Session.—Geology (3), political economy (3), astronomy (4), embryology (4). Practicum—Geology (5), embryology (6).

Spring Session.—Geology (3), astronomy (3), ethics (3), history of English literature (3). Practicum—Geology (5), thesis.

3.—*Chemistry and physics.*

JUNIOR CLASS.

Fall Session.—Rational mechanics (4), chemistry (3), logic (3), animal physiology (4) or differential calculus (3) (elective). Practicum—Mechanics (4), chemistry (8).

Winter Session.—Physics (4), chemistry (4), natural theology (3) or integral calculus (2) (elective). Practicum—Physics (3), chemistry (19).

Spring Session.—Physics (4), chemistry (4), mineralogy (3), civil government (3). Practicum—Physics (3), chemistry (9).

SENIOR CLASS.

Fall Session.—Physics (3), chemistry (1), geology (3), mental philosophy (3). Practicum—Physics (4), chemistry (18).

Winter Session.—Physics (3), chemistry (2), geology (3), political economy (3). Practicum—Physics (4), chemistry (16).

Spring Session.—Physics (3), chemistry (3), ethics (3), history of English literature (3). Practicum—Physics (3), chemistry (10), thesis.

4.—*Civil engineering.*

JUNIOR CLASS.

Fall Session.—Rational mechanics, differential calculus, descriptive geometry, shades, shadows, and perspective.

Winter Session.—Physics, integral calculus, descriptive geometry, analytical mechanics.

Spring Session.—Physics, analytical mechanics, mineralogy, civil government.

SENIOR CLASS.

Fall Session.—Geology, resistance of materials, principles of mechanism, railroad surveying.

Winter Session.—Geology, construction of bridges, astronomy, political economy.

Spring Session.—Geology, astronomy, hydraulics, ethics.

[Ten hours of practice a week throughout the two years.]

SPECIAL COURSES.

Students of mature years and younger students whose parents or guardians request it are permitted to choose such a special course as they may need. Of every such student it is required that he be prepared to enter upon and pursue with profit the studies chosen, that he have an equal number of hours of class-work with other students, and that he take part in the *practicum* to which he may be assigned. In order, however, to make a still more specific provision for the needs of those who are unable, for any reason, to pursue a full course, there were established in the early part of the year 1882–'83 a short special course in agriculture, of two years, and a similar course in chemistry. In these courses the studies are arranged with direct reference to the student's immediate aim, and of course cannot be largely educational in other directions.

PRACTICAL WORK.

The college has, from the first, sought to combine practical with theoretical instruction, and thus to fix in the student's mind a knowledge of both methods and principles. With this end in view a portion of the student's time has been set apart for this training, and the number of subjects in which such instruction is given and the apparatus for it have been added to until the range of topics is unusually extensive, as appears from the several schedules. A portion of this training is largely technical, and so is almost wholly confined to certain courses. Other parts, however, are so general in their character as to be appropriately required of all students. Among these *practicums* common to all, the following may be mentioned for the sake of illustration: Book-keeping, so important for the right conduct of all business; drawing, freehand and mechanical, needed by individuals in all employments and professions; military drill, required by the law of Congress and helpful in securing right habits of body and mind; mechanic arts, in which are learned among other things the making of plane surfaces, correct angles and joints, and the care and use of tools; horticulture, where instruction is given in all ordinary operations belonging to fruit culture, such as pruning, grafting, budding, and propagation by cuttings and layers; and surveying, which acquaints the student with the instruments of the art and trains him to determine points, distances, and areas. Some of these *practicums* not only give knowledge of almost universal use, but also serve a good purpose by developing, during the early part of the course, tastes and aptitudes which may determine the student's choice of a technical course and of his life work.

In each of the technical courses certain special lines of practice have a large amount of time given them proportionate to their importance or subsequent professional use. Each *practicum* is directed by an instructor who is familiar with both the theory and the practice and with their mutual relations.

FARMERS' INSTITUTES.

In order to meet the wants of farmers who desire to increase their knowledge of the theory of their calling a farmers' institute has been held at the college during the last two winter sessions. This two weeks' course comprises from thirty to forty lectures by the college professors or by others whose services are secured, that they may present to the farmers certain important specialties.

The following topics are among those included in the courses: Agricultural chemistry, botany, dairying, entomology, farm accounts, feeding, fertilizing, fruit growing, grain and forage crops, mechanics, roads and bridges, stock breeding, vegetable gardening, veterinary, drinkable waters, adulteration of foods, political economy for farmers, industrial education, &c. Besides this direct attempt to meet the wants of farmers who are engaged in the active pursuit of their occupation, the college has recently (November, 1882) begun the publication of occasional bulletins containing the results of agricultural experiments and investigations conducted by the professor of agriculture. These bulletins have reached a circulation of upwards of 5,000 copies, and are largely sought for by the most intelligent farmers of the State.

No charge is made for instruction or for the use of the public rooms of the college.

FREE SCHOLARSHIPS.

There have recently been established fifty free scholarships, one for each senatorial district in the State.

The scholar, male or female, is to be appointed by the senator of the district after a competitive examination in the studies required for admission to the freshman class, and must, therefore, fulfill the conditions requisite for admission to that class as given above.

The holder of the scholarship is admitted to the privileges of the institution free of the ordinary charges for incidentals, room rent, fuel, and furniture, this immunity to continue for the entire college course, provided that both conduct and class standing be satisfactory to the faculty. Other expenses, such as boarding, books, and light, must be borne by the student.

A vacancy may be filled after the opening of the college year if the appointee's attainments are sufficient for admission to the class at that time.

For information as to vacancies, time and place of examination, &c., candidates for a scholarship apply to their senator, in whose care the details of appointment are placed by the college.

MILITARY INSTRUCTION.

In addition to the exercises in the schedules of the several courses, all students, except those exempted because of conscientious scruples or physical disability, take part in military drill. The exercises occur, ordinarily, three times per week. Seniors and juniors are required to be present at but half the number of regular exercises assigned for members of the lower classes. The uniform used is of cadet gray cloth and of a standard pattern.

LABORATORY EXPENSES.—Students in the laboratories pay a small charge for their outfit; also, for apparatus destroyed and material consumed by them.

BOARDING.—The college does not maintain a boarding-hall, and most students depend upon the boarding-houses in the vicinity, the regular charge being $3 per week. The college offers special facilities to those who board themselves singly, and also to the College Boarding Club, which supplies its members, now numbering about twenty, with good boarding at about $2 per week.

FURNITURE.—The furniture provided for students who room in the building consists of a bedstead, mattress, table, washstand, and chair. The student provides all other articles, including bedding, wash-bowl and pitcher, mirror, lamp, &c.

MEANS OF ACCESS.—The turnpike from the college furnishes daily communication by stage with Bellefonte, which is connected by two trains daily with Tyrone, on the Pennsylvania Railroad, and with Lock Haven, on the Philadelphia and Erie Railroad.

Owing to the better accommodation and greater regularity of communications, the route by Bellefonte is now preferable for all those coming by railroad. The Lewisburgh and Tyrone Railroad runs within six miles of the college, and furnishes regular passenger trains from Tyrone.

EXPENSES.

Fall Session:	
Incidentals	$6
Room rent, fuel, and furniture	9
Winter Session:	
Incidentals	4
Room rent, fuel, and furniture	11
Spring Session:	
Incidentals	4
Room rent, fuel, and furniture	6

There is no charge for tuition in any course. The charge for incidentals is intended to cover the expenses of heating, lighting, and caring for the corridors and the recitation and other public rooms. This is the only charge made to pupils who do not room in the college.

The above charge for room-rent, fuel, and furniture is made to those who room in the building, and is on the basis of two persons to each room. In cases where a student rooms alone, he is charged $4 additional per session.

INSTRUCTION OF WOMEN.

Ladies are admitted to the preparatory and college courses on the same terms as gentlemen. For higher standing, also, the examinations are the same for both sexes, except in those instances in which a difference in studies is noted at the foot of a schedule. It is in contemplation, however, to establish at an early day a somewhat modified course for ladies.

APPLIANCES, ETC.

The building is a plain and substantial structure of magnesian limestone, situated on a pleasant rise of ground, in one of the most beautiful and healthful valleys of the Alleghany region, and is two hundred and forty feet in length, eighty feet in average breadth, and five stories in height, exclusive of attic and basement. It contains the public rooms, such as chapel, library, armory, cabinets, laboratories, society halls and class rooms, and a large number of dormitories.

The tract of land on which the building stands contains nearly three hundred acres. Of this about 50 acres in the immediate vicinity of the building constitute the campus and furnish recreation grounds, sites for the professors' houses and other needful buildings, &c.

The campus contains at present four of these residences of professors, and it is adorned with trees, shrubbery, flower-gardens, walks, and rustic bridges.

The college farm consists of 240 acres, of which 40 acres are woodland. The remainder, except so much as is occupied by farm buildings, orchard, and vineyard, is worked under a system of rotation of crops, in five divisions of 30 to 40 acres each. The soil is limestone, with a large admixture of flint, and is admirably adapted to the production of the various grains and grasses grown in this region. It responds freely to the use of lime, gypsum, and the various artificial fertilizers; but the chief dependence for increase of fertility is placed in barn-yard manure, which is obtained by fattening a large number of beeves each winter.

The farm-buildings include two dwelling-houses, a large and excellent over-shot barn, with double threshing-floor, threshing-house, corn cribs, root-house and stabling, a hog-pen, a slaughter-house, a tool-house, &c.

An orchard of about 14 acres, chiefly of apples, and a vineyard of five hundred vines, are in good bearing condition.

The greater part of the labor upon the farm, orchard, vineyard, and campus is done by paid laborers; but the professors in charge of instruction in agriculture and horticulture make use of all parts of the college grounds for their purposes, but require of each student under their charge only so much of the labor in each place as they deem needful for proper practical training.

EXPERIMENTAL FARMS.

The college has three experimental farms of about 100 acres each, situated in different sections of the State—one in Chester County, one in Indiana County, and one adjoining the college farm. These are intended to test practically some of the doubtful questions that vex agriculturists, to ascertain the value of new processes, to experiment in the breeding and feeding of cattle, to determine the relative value of fertilizers, and, in general, to further, through systematic and continued experiment under varying conditions of soil and season, the interests of progressive agriculture.

RHODE ISLAND.

BROWN UNIVERSITY, PROVIDENCE.

This venerable college was chartered in 1764 and organized in 1765. It received in 1863 the benefit of the national land grant to Rhode Island, and organized its "departments of practical science" in 1869, so as to give instruction in such "branches of learning" as are related to "agriculture and the mechanic arts."

Students who enter only for these studies, either in part or in full, are subject to the same conditions of admission as for any select course; and when they have duly pursued such studies they will be entitled to a certificate stating the time of their university residence and the amount of their acquisitions. They may, however, pursue these studies in connection with "the regular scientific and classical studies of the university," and when they have so pursued them as to fulfill the requirements for the degree of bachelor of arts or of bachelor of philosophy they will be entitled to these degrees.

The State received land scrip for 120,000 acres, which was sold for $50,000. This sum is invested in State securities at interest, and the income is turned over to the university to be expended in the education "of scholars, each at the rate of $100 per annum." Appointments to these scholarships are made on the nomination of the general assembly, by the governor and secretary of state, in conjunction with the president of the university.

The professors and instructors in the schools of practical science are as follows:

Rev. Ezekiel G. Robinson, D. D., LL. D., president, professor of moral and intellectual philosophy.

Samuel S. Greene, LL.D., professor of mathematics and astronomy.

Benjamin F. Clarke, A. M., professor of mathematics and civil engineering.

John Howard Appleton, A. M., Newport Rogers professor of chemistry.

Eli W. Blake, jr., A. M., Harvard professor of physics.

John W. P. Jenks, A. M., professor of agriculture and zoölogy, and curator of the museum.

Charles W. Parsons, M. D., professor of physiology.
Alpheus S. Packard, jr., M. D., PH. D., professor of zoölogy and geology.
Nathaniel F. Davis, A. M., assistant professor of mathematics.
William Whitman Bailey, B. P., professor of natural history (botany) and curator of herbaria.
William Channing Russel, LL.D., acting professor of history and political economy.
William Herbert Perry Faunce, A. B., instructor in mathematics.
Edwin Eddy Calder, assistant instructor in analytical chemistry.

The other professors in the university are those of the Latin language and literature, Greek language and literature, rhetoric and English literature, Elton professor of natural theology, modern languages, and elocution, as well as a librarian and assistant librarian.

The following is a summary of the students attending the present year (1882–'83): Seniors, 52; juniors, 59; sophomores, 68; freshmen, 85; total, 264.

The cost of living varies much according to circumstances; the ordinary expenses are as follows:

Tuition	$100 00
Room rent	20 00
Use of library	5 00
Registrar's salary	4 00
Public fuel, servants' hire, printing—charged at cost, but average about	22 00
Board, 41 weeks, at $3	123 00
Total	274 00

This amount may be much reduced by holding some one of the scholarships shortly to be mentioned, or it may be increased in various ways. If a student occupies a room alone, his rent and servants' hire are doubled; if he rents rooms or suites in Slater's Hall, he must pay from $25 to $155 per annum.

The foregoing estimate for tuition does not include the fees for instruction in analytical chemistry. The expenses of a student who takes a course of study of two hours daily in the chemical laboratory are as follows:

Tuition	$33 33
Gas, chemicals, &c	36 67
Breakage (varying with student's care), about	6 00
Total	76 00

Students who take courses of four or six hours daily pay respectively double or treble the above amounts.

Allusion has been made to the "scholarships of the department of agriculture," as they are termed by the authorities of Brown University.

The amount received as interest is derived from $50,000 at 6 per cent., $501 at 7 per cent., and a variable amount on deposit at 7 per cent. If simple interest at these rates on the sums named be calculated from August 30, 1870, when the final payment for the land scrip was made, to August 30, 1881, it will be found to amount to $32,725, or about $3,000 per annum.

The treasurer of the university for the years ending the middle of April, 1873, 1877, and 1878 reports to the corporation as follows:

Year.	Income.	Disbursement.
1873	$3,381 22	$2,300 00
1877	3,287 32	3,300 00
1878	3,248 60	4,500 00

At the latter date there was a balance of income remaining and available of $4,859.33.

The expenditures seem to have been so kept within the income as to increase the fund at interest every year, and thus gradually increase the number of persons benefited.

In addition to these there are 66 scholarships of $1,000 each, the income of which is given, under the direction of a committee appointed by the corporation, to meritorious students who may need pecuniary assistance; but a scholarship is forfeited if the candidate incurs college censure or fails to secure at least seventy-five per cent. of the maximum mark.

There are also scholarships arising from the income of $12,300 given by Henry R. Glover, Mrs. E. S. Bartlett, and others, on various conditions.

Finally, a fund of something over $8,000 has been given to the university by two of its friends. The income of this fund is to be applied, either by loan or by gift, to the assistance of deserving young men of limited means.

It is needless to say that Brown University teaches a thorough classical collegiate course, after the conservative fashion. It is only necessary here to mention at some length its "departments of science," already alluded to.

I.—CHEMISTRY APPLIED TO THE ARTS.

The chemical laboratory is open to students (except on Sundays) from 8.30 a. m. to 2.30 p. m.

It is the design of this department to teach students analytical chemistry, and then to direct their studies to the practical applications of chemistry.

Attention is given to metallurgy, pharmacy, medical chemistry, agricultural chemistry, and the application of chemistry to manufacturing processes.

II.—CIVIL ENGINEERING.

The regular course in this department occupies four years, but a longer or shorter course may be pursued, according to the wants or abilities of students. Those who are unable to pursue a full course will find the studies so arranged that the knowledge and practice acquired in only a partial course will be practical and available. Ample provision will be made for the instruction of any who desire a more extended course than is here indicated in engineering and in higher mathematics.

III.—PHYSICS.

The laboratory of the department of physics provides instruction during the second half year to a limited number of students who show special aptitude for this study, and are desirous of familiarizing themselves with the construction and use of physical apparatus and with the means of investigation.

A course of experiments in sound, light, heat, and electricity, involving the principal phenomena and most important methods of measurement, has been arranged with reference to the needs of beginners. Apparatus available for more advanced students and for researches has been purchased recently, with the view of meeting the demand for special instruction in physics.

IV.—BOTANY.

Instruction in botany is given by means of lectures, in which free use is made of the blackboard and diagrams. The course embraces the necessary morphological and physiological subjects, and is supplemented by practical class work, in which each student employs the dissecting microscope in examining specimens.

Great stress is laid upon the importance of drawing from nature, and students are taught to make illustrative sketches.

Each student of botany is expected to pay a small fee for the cost of specimens used in class work.

At the proper season excursions are made, under the guidance of the professor, to neighboring points of botanical interest. At such times students are shown how to collect and preserve specimens.

V.—ZOÖLOGY AND GEOLOGY.

Zoölogy, with special reference to palæontology, is taught by lectures, laboratory work (forming a course of comparative anatomy), and by dredging and collecting excursions in Narragansett Bay and near the city, with special reference to the local fauna.

Instruction in geology is given by means of lectures and models, laboratory work, and field excursions, with special reference to the geology—structural and economic—of Rhode Island.

VI.—AGRICULTURE.

The course of instruction in agriculture includes the courses in the preparatory branches, chemistry and physics, botany, physiology, geology, and comparative anatomy.

It also includes special lectures on agriculture. These relate to the study of soils and applied economic geology. The course of instruction is illustrated by specimens from the museum of natural history and by field excursions.

It also includes practical instruction in obtaining and preserving specimens and in taxidermy.

SOUTH CAROLINA.

UNIVERTITY OF SOUTH CAROLINA.

The income of the proceeds of the land grant to South Carolina is now divided between the South Carolina College of Agriculture and Mechanics at Columbia and the Claflin College at Orangeburg.

These colleges, by the State law of March 22, 1878, are branches of a corporation styled the University of South Carolina, under the control of a board of trustees consisting of the governor, the State superintendent of education, the chairmen of the committees on education in both branches of the legislature, and seven other persons chosen by joint vote of the legislature. This board is created a body corporate and politic, with power to hold property, real and personal, and is the successor of the former University of South Carolina, of the College of South Carolina, and of the agricultural college at Orangeburg. It has the power to appoint and remove officers and professors in the colleges, to organize the colleges as shall be deemed best, and to confer degrees. The board may select ten professors and two presidents for service in the colleges at Columbia and Orangeburg, and these are paid from the treasury of the State.

The donation of land-scrip by the general government for the establishment of colleges of agriculture and the mechanic arts, under the act of July 2, 1862, was accepted by the State; and the law of December 10, 1869, directed that the proceeds of the sales of the scrip should be invested in Federal or State bonds bearing 6 per cent. interest. In 1870 the scrip was received, sold, and the proceeds, $191,800, invested in State bonds, on which the annual interest amounted to $11,508, the interest to begin July 1, 1870. The interest was not promptly or regularly paid, and the principal was irregularly used to meet the demands and obligations of the State treasurer, so that, ten years after, the legislature, on December 23, 1879, passed an act appropriating $191,800 in State stock, at 6 per cent. interest from July 1, 1879, to replace the principal; but the deficiency in interest, amounting to $58,736, was not reimbursed. The act just cited provided that the board of trustees should open a college for white students at Columbia as well as the one for colored students at Orangeburg, and use the property of the former State University as might be found necessary for this purpose. Tuition in the college was made free, and scholarships were also authorized.

COLLEGE OF AGRICULTURE AND MECHANICS.

The first session of the new college began Tuesday, October 5, 1880, with the following corps of instructors:

1. William Porcher Miles, LL. D., president and professor of English literature.
2. James Woodrow, PH. D. (Heidelberg), D. D., professor of geology, mineralogy, botany, and zoölogy.
3. Benjamin Sloan (U. S. M. A.), professor of mathematics and natural philosophy and secretary of the faculty.
4. William Burney, PH. D. (Heidelberg), professor of analytical and agricultural chemistry and experimental agriculture.
5. G. W. Connors, foreman of the farm.
6. Jesse Jones, foreman of the shop.

Two instructors, licensed by the college, give lessons in ancient and modern languages, the compensation therefor being a personal matter between the teachers and students.

The ordinary course of instruction in the college is open to applicants not less than fifteen years old who have passed a satisfactory examination in English grammar, geography, arithmetic, and algebra through equations of the second degree. Some familiarity with English and American history will be found useful. The following is the course of study, occupying three years:

First Year.—English history, rhetoric, composition and declamation, algebra, geometry.

Second Year.—Logic, political economy, declamation, mineralogy, botany, trigonometry, descriptive geometry, shades and shadows, surveying, inorganic chemistry.

Third Year.—Mental philosophy, English literature and language, zoölogy, geology, general geometry, differential and integral calculus, applied mathematics, organic chemistry, agricultural chemistry, analytical chemistry, both qualitative and quantitative.

The following extracts from a letter of President Miles shows something of the spirit and vigor with which the new college is working for the benefit of its pupils and the State at large:

"From the many letters of inquiry which I receive, it would seem that there has been

little or no mention of this, our only State college for whites, in the local newspapers, and no attempt to present to our impoverished people the advantages afforded them of educating their sons gratuitously. I cannot but believe that if the course of instruction and the qualifications of our professors and instructors were more generally known, there would be many a poor young man—desirous of a liberal education, and at the same time unable to pay for his tuition—who would gladly seek our lecture rooms, where thorough instruction in so many of the most important branches of human knowledge is freely tendered him 'without money and without price.'

"For enabling our students to acquire practical acquaintance with planting and farming, and the methods of cultivating our staple crops, we have an ample area of land, where Mr. Connors, our farmer, an experienced and skilled agriculturist, gives his undivided attention to field and garden operations. Here the lectures on agricultural chemistry are supplemented and illustrated by the test and comparison of various fertilizers on growing crops. We do not propose to make our farm an 'experimental farm,' as that term is unusually understood, *i. e.*, a collection of little, minute squares of ground, where curious and fanciful experiments are to be made, such as Liebig might have made in pots of earth in his laboratory. We will rather aim to teach our young men who propose to follow planting or farming as a means of livelihood the most approved and successful methods of raising remunerative crops, as well in the preparation of the soil (often half the battle) and best use of farming implements in all stages of the crops (from seeding to harvesting and preparing for market) as in the supplying of all the requisites of plant food.

"There is a dawn of a new era in the agriculture of our State. Our gifted and distinguished fellow-citizen, Dr. St. Julian Ravenal, has demonstrated, by repeated trials, that sixty to seventy bushels of oats, and other grains proportionately, and from four to five tons of hay, may be raised on an acre of land (by proper treatment and an application of by no means expensive fertilizers) where without such treatment and application hardly a tenth of such yield could be had. Bermuda grass may yet be destined to work a revolution in our agricultural industry. It is now indigenous to our soil, thoroughly acclimated, indestructible by winter frosts or summer suns and droughts, requiring but moderate care to nurse it into a luxuriant growth, with which timothy cannot compare. The marked success which has attended its culture, on a large scale, by Governor Hagood—one of our most enlightened and educated and at the same time practical farmers—has long taken this question of Bermuda grass hay out of the hands of the experimenter and the domain of theory. And in this connection I may be permitted to add that Governor Hagood, as chairman *ex officio* of our board of trustees, takes not only a deep interest in our farming operations, but kindly aids the foreman of the farm with continual practical advice and suggestions. I trust you will pardon me for dwelling at such length on the agricultural feature in our institution, but it seems to me worthy of the extended notice I have given it.

"Mr. Jesse Jones, a thoroughly skilled and unusually ingenious mechanic and machinist, is our master mechanic, and has charge of the workshop, where, under his eye, the student learns the use of all ordinary tools and how to handle them, and how to plan and construct farm buildings, and to make and repair farming implements, &c., and where, gradually, a practical acquaintance with engines, mills, and machinery generally may be acquired.

"When our people shall have become thoroughly awakened to the necessity of providing the means of education of the highest grade to the poorest classes of her citizens free of expense, so that there can never more be even the excuse for the cry that the college at Columbia is 'an aristocratic institution,' 'the rich man's college,' &c., then we may see our legislature, in imitation of the legislatures of our sister States of the South, making provision herself, in addition to the congressional aid by which we are at present solely supported, for enlarging the scope of instruction in our walls, and making the College of South Carolina an institution of high and liberal culture, of which her people may be justly proud, and for which unborn generations of her sons will be grateful."

* * * * * * *

"Let there be only a generous rivalry among us to see how much each of us can do towards stimulating the youth of our State to the desire for and the pursuit of that 'higher education' without which a people must inevitably retrograde, not only in intellectual, but in material progress. For if there be one thing in the present age of the world more certain than another, it is that mind rules not only the forces of the social and political world, but to an even greater extent the forces of nature. Show me the nation where the intelligence of the mass of the people is most developed by training, *i. e.*, where thorough education is most diffused, and I will show you a nation most advanced in even material wealth and prosperity. Let us multiply our schools and colleges, then, say I. We cannot have too many of them. In education the aphorism 'Too much of a good thing' does not hold. Who would oppose the building of a new church on the plea that there

were churches enough already? Is the plea any stronger in the case of colleges, especially in a State where the young men are growing up in such general illiteracy? No; let us educate—educate in common schools, in private schools, in high schools, in normal schools, in colleges, in universities—everywhere educate! And especially let our mother, the State, extend to the poorest boy on her soil such advantages in the way of education as may enable him to compete in a professional or public career, in any pursuit and in every way, with the richest and proudest in the land."

The number of students for the first session of 1880–'81 was 66, all males, women not being admitted to this college.

COLLEGE AND MECHANICS' INSTITUTE OF CLAFLIN UNIVERSITY.

The other branch of the University of South Carolina is the "Agricultural College and Mechanics' Institute" at Orangeburg.

In the year 1869 an institution was opened for the general instruction of colored youth; this was endowed chiefly by gifts of money from persons in the Northern States, among whom was the late Lee Claflin, of Massachusetts. This school was chartered as Claflin University and has continued with varying fortune until the present time. After the State accepted the agricultural land grant, as already mentioned, the Agricultural College and Mechanics' Institute was organized in 1872 as a coördinate branch of Claflin University. Appropriations were made for some years at irregular intervals, being scarcely sufficient to purchase the agricultural farm. When Governor Hampton came into power the matter assumed a little more regularity, and $5,500 have been appropriated annually from the agricultural fund to sustain the institution.

The faculty of the institute (and of the Claflin University as well) for the session of 1880–'81 was composed of the following persons:

Rev. Edward Cook, A. M., D. D., president, professor of ethics and agricultural topics.

Rev. William H. Lawrence, A. M., professor of Latin, Greek, and German languages and literature.

William J. De Treville, jr., C. E., professor of pure and applied mathematics.

Rev. James H. F. La Roche, A. B., professor of natural science.

James S. Heyward, adjunct professor of mathematics.

Miss Sarah G. Bagnall, preceptor in English literature and French.

The very low standard of attainments among the colored people has obliged the institute to take up the work of education where it is left by the poorly supported and defective common schools of the State. As time has passed some of the pupils have been prepared for the higher courses of study, and every effort seems to have been made to utilize the resources of the university for the benefit of its pupils. At least two-thirds of these are classed as attending the grammar school, which has a course of two years, namely:

First year.—First, second, and third readers; orthography—word primer; arithmetic—progressive primary.

Second year.—Arithmetic—rudiments of written arithmetic; English grammar—language lessons; orthography—word book; geography—primary; reading—fourth reader; penmanship—Reynolds' series.

The earliest and most persistent necessity for the colored people has been well instructed teachers for the public schools; Claflin University has provided, almost since its foundation, a normal school course of three years' duration.

First year.—Practical arithmetic; intermediate geography, completed; new English grammar; dictionary and dictation exercises; school reader No. 5; advanced penmanship.

Second year.—Arithmetic, completed; algebra, begun; English grammar and word analysis; English and Saxon prefixes, suffixes, and derivations; history of the United States; introductory Latin book; Latin and Greek prefixes and derivations; word analysis, parts II, III; drawing and elocution.

Third year.—Algebra, completed; physiology; natural philosophy; chemistry; rhetoric, English history and literature; drawing, orations, and essays.

Pupils completing these courses, or possessing an equivalent training, are admitted to the scientific and agricultural course, which occupies four years. Those who desire to pursue the classical collegiate course omit all the studies of the third normal year, except the algebra, and substitute the following: Harkness' Latin Grammar and Reader; Cæsar's Commentaries; Cicero's Orations against Catiline; Boise's First Book in Greek; Xenophon's Anabasis; Grecian mythology; Grecian and Roman history.

The following list shows the studies pursued in the institute (scientific and agricultural) and the collegiate (classical) courses:

Freshman year.—Higher algebra; plane geometry; rhetoric and composition; physiology; physical geography; French language and literature; bookkeeping; farm and me-

chanical work; Æneid of Virgil; Cicero de Officiis; Latin grammar and composition; Xenophon's Memorabilia; Homer's Iliad.

Sophomore year.—Solid and spherical geometry; trigonometry, plane and spherical; surveying and navigation; English history and literature; rhetorical exercises; French and German languages; drawing, freehand and mechanical; farm and mechanical work; Livy; Horace, Odes and Ars Poetica; Demosthenes, de Corona; Thucydides' histories.

Junior year.—Conic sections; mechanics; natural philosophy and astronomy; compositions and declamations; French and German languages; Tacitus, de Oratoribus and histories; Greek historians or French and German.

Senior year.—Chemistry; geology, mineralogy. lectures; logic; mental philosophy; moral philosophy; Government Class Book in Civil Polity; orations before the college.

Though the law of 1879 makes the institute a part of the University of South Carolina, it still continues in practice, a department of the older corporation, Claflin University. The grounds and buildings of the institute (aside from those of the university) are worth at least $10,000; these comprise a farm of one hundred and sixteen acres, a large barn, a stable and carriage-house, four dwellings, and two small storehouses. The university proper owns thirty-seven acres, one large brick building containing chapel, lecture rooms, laboratory, and president's quarters, and four dormitories. A grammar school building has been erected recently.

Thus far the double connection of the institute does not appear to have resulted badly, either for its interests or for those of its patrons, the union between the State and the Claflin corporation being both pleasant and profitable.

Admission to all classes, both in the university and the institute, is free to both sexes. The catalogue of 1880–'81 shows 18 male and 2 female students in the collegiate course; 87 men and 39 women in the normal classes, and 150 boys and 92 girls in the grammar school. A recent letter from the president says:

"With what can be earned in the industrial department, a student can get along comfortably with about fifty dollars additional a year. The scholarship is advancing rapidly and the institution is doing a great work for the colored youth of South Carolina.

"It has the confidence and moral support of the white citizens as well as the colored people."

TENNESSEE.

UNIVERSITY OF TENNESSEE, KNOXVILLE.

[Statement of the president.]

* * * The college established in this university, according to the contract made between the trustees and the State of Tennessee and maintained with the income from the national endowment, by act of Congress approved July 2, 1862, is now in a healthy condition and useful operation. The trustees determined from the beginning to conduct it with faithful adherence to the provisions of that Congressional act. They sought, therefore, to provide, first, for instruction in such branches of learning as are related to agriculture and the mechanic arts, "without, however, excluding from the field of teaching other classical and scientific studies, and at the same time including military tactics." Upon this basis the institution has been conducted from 1869 to this time.

The college grounds, buildings, and farm have been provided by the trustees of the university as required of them by the law of the State. The present value of this property is not easily determined with accuracy. It may, however, be placed at $120,000.

The endowments that yield income for the use of the college consist, first, of $9,000, owned by the university for many years past, and which may be applied to building purposes; and, second, of $396,000 in bonds of the State of Tennessee, bearing 6 per cent. interest, and $4,000 in bonds of the same kind, bearing 5 per cent. interest, in which bonds, the proceeds of the sale of the land scrip received by the State of Tennessee from the United States under the act of Congress of July 2, 1862, have been invested. The annual income from this fund, which exists in perpetuity for the maintenance of the college, is $23,960, and cannot be applied to building uses.

The income from college fees for the year ending July 1, 1882, was $2,891.68; the library fund yielded $311.45. The aggregate income for that period from all sources (including cash on hand at its beginning) was $34,890.81.

The expenditure for the year ending July 1, 1882, including payments for the farm, the library, for repairs and improvement of buildings and the construction of gas-works, was $34,383.46.

The expense of the teaching corps, for the same time, was $19.890; the number of instructors was fourteen; the chairs were as follows, viz:

Ethics and evidences of Christianity (filled by the president); agriculture and horticulture; mathematics and mechanical philosophy; chemistry, mineralogy and geology; history and philosophy; English language and belles-lettres; modern languages and comparative philology; ancient languages and literature (assistant); mathematics; military science (the professor being also commandant of cadets). There were also two instructors, one in English and one in ancient languages; one in vocal and instrumental music, and an assistant in analytical chemistry.

The number of students in all departments of the college for the same period of time was 225; all of these were males. No provision has been made, specially, for the instruction of females in technical or industrial branches of learning, nor has any female applied at any time for admission as a student. If such provision were made the applications would probably follow.

The average expense of tuition to students in the preparatory department is $30 a year, and hereafter it will be the same to students in the college proper, to all of whom it is now free.

The State is entitled to 275 scholarships tuition free. Each State senator may fill two of these, and each representative, three. The State appointees have on some principal railroads free transportation one way, and when needful both ways and on another chief road, nearly half rates both ways.

The number of graduates since the receipt of income from the national endowment of July 2, 1862, *i. e.*, since 1871, is 108. Of these there were in 1880—

Teachers	22
Lawyers or students of law	22
Merchants or clerks in mercantile houses	9
Farmers	9
Physicians, dentists, druggists, and medical students	6
Christian ministers, including 1 theological student	3
Business agents, (railroad, insurance, &c.)	3
United States Government clerks	2
Editors and newspaper reporters	2
Tanner and harness maker	1
Attaché of United States minister to Turkey	1
Student at German university	1
Surveyors and civil engineers	2
Unknown, 3; deceased, 1	4
	87
Deduct for twice counted	7
	80

Of the students who have withdrawn from the college without graduating, fewer in proportion to the above have entered the profession of law, more have become farmers, mechanics, traders, clerks, &c., and a considerable number are teachers.

The course of instruction is divided among the following schools, or departments, with the following hours per week in each, for forty weeks, viz:

Departments.	Freshman.	Sophomore.	Junior.	Senior.
1. Mathematics	5	3	2	.....
2. Applied mathematics and mechanics	3	2	3	5
3. Chemistry and mineralogy	2	3	2	3
4. Natural history and geology	2	3	.....	5
5. Agriculture and botany	.....	3	5	3
6. English language and belles-lettres	3	2	3	.....
7. History and philosophy	.....	.....	5	5
8. Modern languages—				
German	.....	3	2	.....
French	.....	2	3	.....
9. Ancient languages—				
Latin	5	3	2	.....
Greek	5	3	2	.....
Philology	.....	.....	.....	2

Preparatory course: One year in mathematics, Latin, Greek, English and elementary science.

Students may take either (1) a science course, (*a*) mechanical, (*b*) agricultural, or (2) a classical course, according to prescribed studies; or (3) an elective course.

The collegiate year is divided into two terms of twenty weeks' each, without intermission between them. The course of study is continuous throughout the year.

The means for practical application of instruction and studies are as follows:

1. *The agricultural department.*—A farm of 260 acres, well stocked and furnished with all needed agricultural implements, machinery, &c., also thorough-bred cattle, 2 Devons (bull and cow), 7 short-horns (2 bulls, 3 cows and 2 calves), and other more numerous cattle. The land is of fair quality, well improved, convenient, and admirably adapted to stock-raising, and for the growth of the grasses, cereals, fruits, and all other crops required to exemplify and enforce the class-room instruction in theoretical agriculture. Several acres are for experimental purposes, and there have been made or are in progress 120 experiments in wheat, 4 in oats, 12 in grass, and 8 in cattle-feeding. Remunerative labor is furnished to students on Saturdays at about 8 cents an hour.

The means of practical instruction in pomology, horticulture, and botany consist of an orchard of 300 fruit trees, including all kinds; a vineyard of one-quarter of an acre; a small hot-house, and a flower-garden.

2. The *department of mathematics and mechanical philosophy.*—Considerable practice is given students in the solution of original and selected problems in all branches of pure mathematics. The graphical solution of problems in geometry, plane trigonometry, and descriptive geometry initiates the course of mechanical drawing. In the school of applied mathematics there are provided two compasses, one transit, one Y level and leveling staff, one plane table and two chains, which are practically used in plane and topographical surveying, surveying of lines for roads and railroads, including running of curves, making sections and profiles for excavations, embankments, &c. In the school of physics and theoretical mechanics the apparatus is sufficient to illustrate all branches of the subjects by experiments, but is not adapted to original investigations.

Topographical drawing is taught (1) with the pen, (2) with brush in colors. Mathematical drawing is taught in shades, shadows, and perspective, with right line, pen, and brush. Instruction is also given in machine and constructive drawing.

There is a small workshop, provided with a work-bench, a kit of carpenter's tools, an iron vise, a turning lathe, a circular saw, and a fret saw, which are used by the professor in preparing appliances for illustrative experiments, and by his students in manufacturing pieces of apparatus.

3. *Department of natural history and geology.*—The means of practical instruction consists of maps, globes, and charts; models of the human body and its various organs; skeletons and preparations in alcohol of various animals, in whole or parts; collections of insects, and lithological and paleontological specimens, two microscopes, and chemical reagents. Physiology and zoölogy are practically taught in the breeding and feeding of domestic animals and the care of them in health and disease.

4. *Department of chemistry and mineralogy.*—The laboratory is large and provided with work-tables sufficient to accommodate the professor, his assistant, and 14 students at one time. It is also well stocked with apparatus and materials for all the requirements of qualitative and quantitative analyses by the gravimetric method and enough apparatus for volumetric analyses, both of liquids and gases.

For assaying and instruction in metallurgy there is a furnace room provided with apparatus and materials necessary for the valuation of ores and for crucible operations.

Practical mineralogy is taught by means of a collection of about 500 minerals. Determinative mineralogy is taught in the laboratory. * * *

THOS. W. HUMES, *President, &c.*

The following letter explains itself:

UNIVERSITY OF TENNESSEE,
Knoxville, Tenn., September 19, 1882.

Rev. THOS. W. HUMES, S.T.D., *President, &c.*:

In accordance with your request I submit changes and improvements in the department of applied mathematics since 1879.

1. The departments of pure and applied mathematics have been separated, each being now under the direction of a full professor.

2. The department of applied mathematics, of which I am professor, embraces the following subjects: Experimental physics, theoretical mechanics, astronomy, surveying, descriptive geometry, shades, shadows, and perspective, civil engineering, topographical drawing with pen and brush, mechanical and engineering drawing, and field practice with instruments in surveying, leveling, laying out of roads and railroads.

3. The physical apparatus has received valuable additions amounting to about $1,000 worth. These additions embrace important pieces of apparatus in illustration of the principles of electricity, magnetism, heat, and light, and an excellent college telescope, the latter costing $350.

4. Since I have been enabled to devote my time and attention exclusively to the branches of applied mathematics, considerable additional work has been done in practi-

cal work and drawing, and the students have made free use of the telescope in observations.

5. A number of graduates in the course of civil engineering have adopted the profession of engineering, and all of them are now in employment and are doing well.

6. The number of candidates for the degree of bachelor of civil engineer in the class of this year is four.

Respectfully,

S. W. LOCKETT,
Professor of Applied Mathematics.

TEXAS.

STATE AGRICULTURAL AND MECHANICAL COLLEGE, COLLEGE STATION.

The object of the State Agricultural and Mechanical College of Texas is to supply theoretical and practical professional training in agriculture and the mechanic arts. The endowment fund consists of $174,000, invested in Texas 7 per cent. gold bonds, and $35,000 in Texas 6 per cent. bonds. The former sum was realized from the investment of the proceeds of the national land grant; the latter from interest accrued on the original endowment previous to the organization of the college. The annual income from the $209,000 is $14,280. This amount is augmented by receipts from matriculation, incidental, and other fees, and by appropriations. The expenses of the teaching staff for the year 1880 were $12,000.

The college employs professors of the following subjects: Moral philosophy and political economy; English language, history, and literature; ancient and modern languages; physics and chemistry; mathematics; mechanics, engineering and drawing; scientific and practical agriculture and horticulture; and military science, A farm superintendent and a foreman of the shops are included among the officers of the college. The number of students in attendance in 1880–'81 was 127. Of these 1 was a senior, 14 were juniors, 29 sophomores, and 83 freshmen. The total attendance increased to 258 during 1881–'82, owing to changes in the length and character of the course of instruction, the provision for State free scholarships, and the wider acquaintance of the people with the college. The scholarships provided by the legislature in 1881 were 93 in number. One-half of the beneficiaries are required to take the agricultural course and the other half the mechanical. They are maintained and instructed free of charge. Maintenance includes board, fuel, washing, and lights.

The college offers a mechanical and an agricultural course of study, each three years in length. The studies common to the two courses during the first year after admission are arithmetic, algebra, geometry, United States history, English grammar, composition and declamation; during the second year, geometry, trigonometry, surveying, physics, chemistry, history, and rhetoric; during the third year, astronomy, geology, English literature, and the constitutions of the State and the United States. Mechanics comes in the second year of the agricultural course and the third of the mechanical.

The special studies of the agricultural course are as follows: First year, breeds of horses, cattle, sheep, and swine; soils, their formation and classification; history of agriculture and structural botany. Second year, practical agriculture, farm irrigation, field crops, fertilizers, tillage, drainage, dairying, and zoölogy. Third year, farm engineering, farm management, nursery business, meteorology, veterinary science, entomology, rural law, and forestry. Practice in the use of farm machinery is given during the first year; in garden, orchard, and farm culture during the second year, and in experimental work during the third year.

The special branches of the mechanical course are drawing, engineering, and shop practice. Drawing is taught through the course, beginning with freehand and mechanical and ending with machine drawing and designing. The engineering instruction is given in the third year, and includes civil engineering, with field work, and the consideration of mills and mill work, the steam engine and iron. The practice of the first year is in the making of elementary constructions in wood and in the use of wood-working machinery; of the second year, in metal work, mill work, steam enginery, and the use of machine tools; of the third year, in special constructions with machines.

Among the means of illustration and practical instruction are mineralogical and geological cabinets, a chemical laboratory equipped for analytical work, a physical laboratory with valuable and extensive apparatus for illustrating the laws and phenomena of which that science treats, engineering instruments, a drawing room supplied with tables, models, and instruments, a farm of 2,416 acres (230 under fence), gardens, orchards, and vineyards,

and a series of shops with tools, wood and metal working machinery, and a steam engine. The college building consists of the main edifice, the mess-hall, president's house, and five professors' residences, all of brick, costing about $160,000; two wooden barracks of twenty-four rooms each; a farmer's residence, a bath house, and a stable.

The president of the college in a recent report speaks of its needs as follows:

"For the mechanical students we need larger shops and a greater number of tools, machines, and appliances. For the practical study of the sciences, chemistry, physics, botany, geology, mineralogy, we need a spacious laboratory to itself, with various apartments thoroughly provided with the most approved and latest instruments of physical research, models, specimens, chemicals, &c. The department of civil engineering is suffering badly from the want of more instruments for field work. The library needs the constant addition of new scientific works as they appear, and the regular standard scientific journals. Quarters for 200 more students, for professors and officers, and for the sick; apparatus and material for giving instruction in printing and in the use of telegraph and telephone; live stock for the farm; and the means of artificial irrigation—these are only the most urgent needs which must be satisfied if the college is to do well and profitably the great work which is expected of it by our people."

Of the department of agriculture and horticulture the professor in charge makes the following statements for the year ending June, 1881:

"I have during the whole session given instruction in agriculture and horticulture to those of the older students who have chosen the agricultural course. The class numbered in the first term eight members; three of these left college during the session, leaving only five at present. As laid down in the catalogue of last year, all the freshmen are also in the agricultural course, but being hard pressed with studies in the fundamental branches, it was thought best to defer the technical studies till they were better prepared to take them up. The subjects gone over during the first term in agriculture were: The soil, its constituents, origin and formation, classification, and physical properties. We next completed a course in drainage. Both subjects were taught by lectures. In the second term the class received full instruction in vegetable gardening and irrigation. The former was taught by lectures; for the latter we used Stewart's text-book. It has been my object throughout to make the instruction as practical as possible, and the class room has been complemented by frequent illustrations and outdoor work; especially is this the case with the gardening. It gives me pleasure to add that the class has made very satisfactory progress.

"Practical instruction in farm and garden operations has also been given to students in agriculture for four hours each week during the past term. They have thus grafted a number of pear stock, which were purchased for that purpose, a work which proved highly interesting; they received instruction in the formation and care of hot-beds and cold frames; they assisted in pruning the orchard, in the planting of the seeds and care of vegetables, &c., and they have also had practice in handling plows, cultivators, mowers, and other farm implements.

"The total area under the plow this year is 53 acres, divided between the following crops, viz: Corn, 24 acres; oats, 3 acres; cotton, 2 acres; millet, 3 acres; vegetables and experiment plots, 10 acres; and orchard, 11 acres.

"There are now 25 varieties of grape vines in the garden, of which 20 varieties are from cuttings purchased this spring, and therefore still young plants. The object is to increase the stock by propagation till we can plant a vineyard, and also to add to the number of varieties, so as to compare them together and report upon their merits. The orchard is in a fair condition, and will this year bear a little fruit."

Of the industrial department the following report is given:

"The duties of this department are, to a great extent, planned with reference to illustrating and applying the scientific principles taught in the class room. All instructive labor is regarded as compensated by the instruction given and the skill acquired. Manual labor is not compulsory, but students who desire to help defray their expenses by work can do so by taking part in the uninstructive labor, such as ordinary farm operations, repairing, carpentering, painting, janitor's duties, and stock management, at fair wages. This can be done at extra hours and on Saturdays, without interference with regular studies and duties.

"Instructive and uninstructive duties will be supplied in:

"1. *Agriculture.*—General farm operations.

"2. *Horticulture.*—Garden, vineyard and fruit culture.

"3. *Stock and dairy management.*

"4. *Mechanics.*—Carpentering, fencing, painting, &c.

"Four thousand dollars has just been expended by the board of directors for the equipment of the mechanical department with the necessary tools, machinery, engine, and materials. The shops in which systematic practical instruction is to be given are: (1)

carpenter shop; (2) vise shop; (3) forge shop; (4) steam, wood, and metal working machinery.

"The directors have fixed the maximum rate of compensation per hour in the agricultural department at 15 cents; in the mechanical, at 20 cents.

"The object is to assist worthy students in every way possible, but the college cannot guarantee to any one student sufficient labor to meet all his expenses, as labor can be furnished only as long as the interests of the institution permit it. A small amount of labor is annually expected from each student to assist the professor in the ornamentation and improvement of the grounds. Agricultural students are encouraged to use their spare time in farm work, at fair wages, but will be paid for quantity and quality of work, not for time only. All paid labor will be given by preference to those students needing assistance."

VERMONT.

STATE UNIVERSITY AND AGRICULTURAL COLLEGE, BURLINGTON.

The object of the University of Vermont and State Agricultural College is to furnish the youth of the State opportunities for education in the branches of special importance to them.

The trustees reported its property, exclusive of the Congressional fund, to be estimated in 1882 at $363,000, its lands at $130,000, its buildings at $65,000, and the collections at $50,000. The amount of trust funds was $113,250. The total income for 1879–'80 was $22,110; the expenditure $21,738, of which $17,506 was absorbed by the payment of the salaries of the teaching staff. The proceeds of the national land grant amounted to $135,500. This sum is invested in 6 per cent. State bonds, and the interest is paid to the college by the State treasurer.

The university has faculties of applied science, arts, and medicine. The faculty of applied science consists of the president, who is professor of political and social philosophy, and professors of mathematics, civil engineering, zoölogy, botany and geology, English language and literature, chemistry and physics, modern languages, and military tactics. These professors, excepting those who teach civil engineering and military science, are in the faculty of arts; and their number is increased by professors of Greek and Latin and of intellectual and moral philosophy. A professor of agriculture is to be appointed as soon as a suitable man is found. The faculty of medicine has 26 members.

The summary of students for 1881–'82 is as follows: Seniors, 16; juniors, 14; sophomores, 20; freshmen, 24; unmatriculated students, 3; total, 77. Of these 47 were taking a classical course, 17 an engineering course, 5 a literary-scientific course, 3 a scientific course, 1 a chemical, and 1 a partial course.

The entire college expenses are estimated at from $176.50 to $249 a year—$54 being for tuition and special fees. There are eighteen scholarships, open equally to members of all the collegiate departments.

As has been intimated, instruction is given in the three departments of arts, applied science, and medicine. The first of these has the usual academic course in languages, mathematics, physical sciences, mental, moral, and political philosophy, rhetoric, literature, and history. The second has courses in agriculture and related branches, chemistry, engineering, and mining. Students have full liberty to elect their courses, but beyond this options are not allowed to those who may be candidates for a degree, except that to a limited extent equivalent substitutions may be made by express permission of the faculty.

The department of applied science provides courses of study which fulfill the requirements of the act of Congress granting public land for the maintenance of agricultural colleges. They are in (1) civil engineering, (2) theoretical and applied chemistry, (3) agricultural and related branches, and (4) metallurgy and mining engineering. As the course in engineering is taken by a comparatively large number of students and as the agricultural course indicates the instruction which is afforded to prospective farmers, these two courses are especially worthy of attention. The course in civil engineering is presented in full, and the difference between that and the agricultural course afterward noted. The studies of freshman year are the same for all the scientific courses, and include algebra, geometry, plane trigonometry and surveying, drawing, chemistry, botany, and English studies, including moral philosophy. The special course in civil engineering is as follows:

SOPHOMORE YEAR.—MATHEMATICS: Spherical trigonometry; analytical geometry; calculus. Drawing: Descriptive geometry; plotting; shades and shadows; isometrical drawing; shading and tinting; topographical drawing. Physics: Stewart's elementary lessons.

Astronomy. French or German. English: French on the Study of Words; Shakspere; Chaucer. Field work: Practice with transit and level; topographical surveying.

JUNIOR YEAR.—MATHEMATICS: Geodesy. Mechanics: Weisbach's treatise commenced; resistance of material. Drawing: Linear perspective; plotting; construction of maps; structural drawings. Henck's field book for engineers. Mineralogy, with blowpipe analysis. Physiology. French or German. English: Rhetoric. Field work: Harbor and river surveying; setting out curves; locating a line of railroad, with computations of excavations and embankments.

SENIOR YEAR.—MECHANICS: Strains in bridge and roof trusses; hydrostatics; pressure of earth; stability of walls and arches; hydraulics and hydraulic motors. Drawing: Mahan's stone cutting; graphical statics. Civil engineering: Mahan's building materials; construction of bridges and roofs, roads, railroads, and canals. Geology. English: History and criticism of English literature. Thesis.

The agricultural course differs from the engineering by the substitution of chemistry and physiology for the mathematics, physics, and the larger part of the drawing and field work of the sophomore year; by replacing the mathematics, mechanics, engineering, and drawing of junior year with chemistry, physics, meteorology, and forestry; and by devoting senior year to studies of special use to the farmer. Chemistry is required throughout the year. In the first term, road making, breeding of animals, and the geology and English of the corresponding term of the engineering course are taken; in the second term, political economy; and in the third term, veterinary medicine and surgery, and constitutional law.

The course in metallurgy and mining engineering coincides with that in civil engineering, save that in the last year metallurgy, assaying, and practical mining take the place of special studies in civil engineering. The course in chemistry is presented elsewhere. To meet the wants of young men who cannot leave the farm in the summer or autumn, a course on agricultural subjects is offered for the winter months on condition ten persons desire to enter upon it. The subjects treated would be agricultural chemistry, botany, physics, entomology, stock breeding, dairying, fruit culture, road making, farm accounts, and bee culture. The course is designed to give a general outline of the subjects treated, to point out the true methods of investigation and the most reliable sources of information, and to stimulate and guide private agricultural study.

The university has a library containing over 19,000 volumes; a museum containing some 80,000 specimens, many of them rare and valuable; and a laboratory fitted up with conveniences for manipulation and experiment amply sufficient for those pursuing studies in chemistry.

The agricultural work of the college has passed beyond the instruction of youth and reached the farmers themselves. The faculty have aided in conducting agricultural meetings, giving lectures on veterinary science, fertilizers, the feeding of stock, insects and parasites, social questions, and other matters of general and special interest to the tillers of the soil. Experiments have been conducted, under the supervision of the college, on farms located in different parts of the State. One prominent object was to ascertain the practicability of increasing the fertility of soils by adding those ingredients of plant food which each soil lacks. The results of these and other experiments were published by the leading papers of the State in six articles prepared by one of the professors. They were also published in pamphlet form and extensively distributed. No work undertaken in the interest of agriculture has been more acceptable to the farmers of the State.

The governor of Vermont, in his inaugural message dated October 5, 1882, speaks as follows regarding the University of Vermont and State Agricultural College:

"The act of Congress of July 2, 1862, which gave to Vermont the fund of which the income goes to this institution, provides that this income shall be used for the support of at least one college where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life. November 9, 1865, the legislature passed an act constituting the present institution, and provided that the course of study should be such as shall render the whole instruction in conformity with said act of Congress. In the succeeding February the trustees, in accordance with law, established a professorship of modern languages, a professorship of chemistry and its application to agriculture and the mechanic arts, a professorship of geology, mineralogy, and mining, and a department of military tactics. The next August a professor of vegetable and animal physiology was appointed, and a course of study established embracing laboratory practice in its application to agriculture, analysis of soils, relations of soil to vegetable productions, botany, forestry, habits of domestic animals, insects injurious to vegetation, and also civil engineering. Professional instructors of military tactics

have also been provided, and special winter courses of lectures have been introduced on agricultural chemistry, botany, physics, entomology, stock breeding, dairying, fruit culture, road making, farm accounts, and bee culture, and these courses will be renewed and extended as they are called for. The trustees and officers have been constant and indefatigable in their efforts to comply with the law in letter and spirit.

"At the time of its charter it was an experiment, and many leading men through the State had great fears as to its success, and would have preferred a separate institution. I have conferred with many of them during the past summer, and find that they are now satisfied that the course taken was a wise and judicious one and its results most beneficial, their only regret being the limited number of students who have availed themselves of its privileges. Legislative committees have been appointed to investigate its progress and management, and have found and reported that the trustees and managers have studiously aimed and faithfully labored to comply with their charters and to meet, so far as their means would allow, all the demands for instruction that have been made upon them, and that more than the income derived from the United States fund is annually expended in paying the expenses of the industrial department. The president and professors are always in readiness to respond to calls for public addresses from lyceums, literary, agricultural, and other associations, and in this way do a vast amount of good, and it is to be noted that they uniformly and pointedly enforce the idea of the dignity and nobility of labor.

"Some persons favor an experimental farm to be used in connection with the college, and thoughtlessly reflect on the trustees for not providing one. The United States law provides that not over 10 per cent. of the fund may be expended for land, and that on no pretence whatever shall any part of the land be used for the erection, preservation, or repair of any building. When the State is ready to erect the buildings and assume their preservation we shall doubtless find the trustees ready to provide the land and tutors. Experimental farming had its origin in Prussia thirty years since, and has rapidly extended, until there are now many stations in Prussia, France, England, and our country. They are to be found in our own latitude and climate in neighboring States. Everything of value in the results of this experimental farming is published in agricultural papers, and is easily and cheaply accessible to all. Such work in Vermont would be largely duplicate. Every State that accepted the government fund has largely aided its agricultural college, in some cases to the amount of millions. Vermont has not yet expended a cent. The institution has always kept out of debt, and its management has inspired such confidence that private beneficence is being largely extended to it. Through the liberality of Mr. John P. Howard the old edifice is now being greatly enlarged and almost entirely rebuilt, and the announcement of Mr. Billings's generous gift to the university has just been made public. It has an extensive library, art gallery, laboratory, and a highly successful medical department.

"I respectfully suggest that you take into consideration the propriety of extending some aid to deserving young men of moderate means, to the end that the opportunities here afforded for a higher education may be improved to a greater extent than is now the case. As the senate is based on population, I would mention as one plan that each senator be allowed to name one person residing in his county who should be entitled to tuition in the agricultural college."

VIRGINIA.

VIRGINIA AGRICULTURAL AND MECHANICAL COLLEGE, BLACKSBURG.

[Statement from catalogues and letter.]

"The objects of the college are to afford a fair, liberal, and practical education to young men who mean to be farmers and mechanics, and to put such education within the reach of many who have not the means to obtain it elsewhere. While the authorities by no means underrate liberal general culture, they hold steadily in view the fact that the mission of this school is peculiar, as designed to meet the wants of the industrial classes. Hence, while reasonable provision is made for the liberal studies, chief attention is given to those that have obvious connection with the needs of the educated farmer and mechanic. Consequently every student is expected to meet the requirements for actual manual labor, so far as such labor is imposed as a part of his education."

The sale of the land scrip donated by the national government produced $285,000, which sum was invested by the board of education in State bonds. By act of the general assembly, approved March 19, 1872, two-thirds of this sum was set apart for the establishment and maintenance of the Virginia Agricultural and Mechanical College. The college was to be located at Blacksburg, Montgomery County, on the conditions that the real estate of the Preston and Olin Institute should be transferred to it and that the county of Montgomery should subscribe $20,000 to its funds. These conditions complied

with, the first session began October 1, 1872. After ten years it was deemed necessary to reorganize the institution. This was accomplished in 1882. The expense of the teaching staff is about $14,000, which is two-thirds of the annual income. The original cost of the grounds and buildings was about $100,000.

The number of students in attendance in the session of 1880–'81 was 84; in the session of 1881–'82, 148. The law provides that 200 students from the State may attend free of tuition. Those outside of the State are required to pay $40 per annum. The attendance of students from other States is quite small. The graduates are about 100; they have taken the degree of "graduate in agriculture" or that of "graduate in mechanics;" the degree of A. B. has been added since the reorganization of the college. Probably one-half are engaged in agricultural or mechanical pursuits.

The course of study is framed for those intending to be farmers or mechanics, and to give scientific and literary education and business preparation. It is as follows:

PREPARATORY YEAR.

Arithmetic, English grammar, geography, history of Virginia, orthography, penmanship, elementary algebra, Latin.

JUNIOR YEAR, NEARLY THE SAME FOR ALL.

English grammar and composition, history of United States, Latin, higher algebra, synthetic geometry, elementary physics, elementary course in agriculture, bookkeeping by single entry, commercial calculations, drawing.

INTERMEDIATE YEAR.

Agricultural.—General chemistry, geology, lectures on agriculture, farm practice, rhetoric, history of English language, algebra, synthetic geometry, ancient and modern history.

Mechanical.—Elementary mechanics, algebra, descriptive geometry, drawing, physics, shop practice, rhetoric, English language, ancient and modern history.

Literary and scientific.—Rhetoric, history of English language, French or German, Latin, ancient and modern history, algebra, synthetic geometry, physics, geology, general chemistry.

Business.—Bookkeeping by double entry, business forms, political economy, rhetoric, English language, ancient and modern history, algebra, synthetic geometry.

SENIOR YEAR.

Agricultural.—Lectures on agriculture, horticulture, &c., agricultural chemistry, agricultural botany, agricultural zoölogy, English literature, trigonometry, surveying, farm practice.

Mechanical.—Technical mechanics, industrial chemistry, mineralogy, metallurgy, mechanical drawing, English literature, trigonometry, conic sections, shop practice.

Literary and scientific.—English literature, French or German, Latin, trigonometry, surveying, conic sections, astronomy, psychology, ethics.

Students enter the class for which their preparation fits them, and are promoted as they make attainments ascertained satisfactory by examination.

The course in agriculture of the senior year discusses the formation of soils, the elements necessary to a fertile soil, means of restoring lost fertility, how plants feed and grow, the necessity and methods of drainage, the principles of stock-breeding, and the general business of a farmer's life.

BUILDINGS AND APPLIANCES.

The college is provided with considerable philosophical and chemical apparatus, by the aid of which the lectures on chemistry and physics are illustrated. A farm of over three hundred acres belongs to the college. It is cultivated in part by the labor of the students. Experiments in agriculture, horticulture, stock breeding, and similar matters are made, with a view to the training of the students and the information of the public. The farm is well stocked and has numerous buildings. The other buildings consist of the three principal college structures, five residences for professors, a commencement hall, hospital, and workshops. The latter are provided with a good steam engine and several excellent machines, among them a planer, band saw, spoke machine, and two turning lathes. Much profitable work is done by the students in the shops, by which they gain skill and experience, and supplement their means for obtaining an education.

The students wear a neat and serviceable uniform, and are required to enter the military department and perform its duties, unless exempted for good reasons.

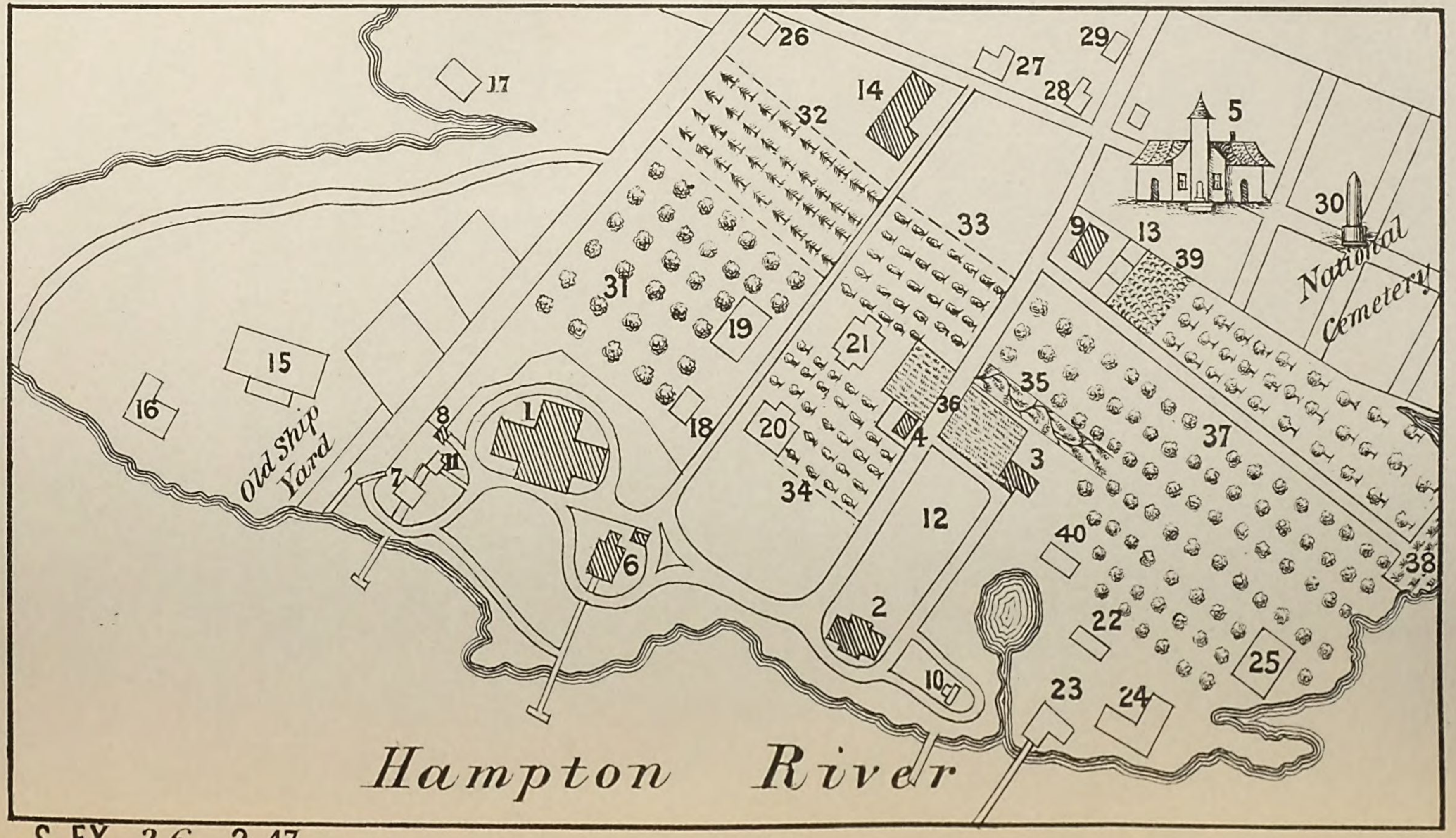
Expenses for a session of ten months, $132.

The college is out of debt and has a large balance to her credit in the treasury.

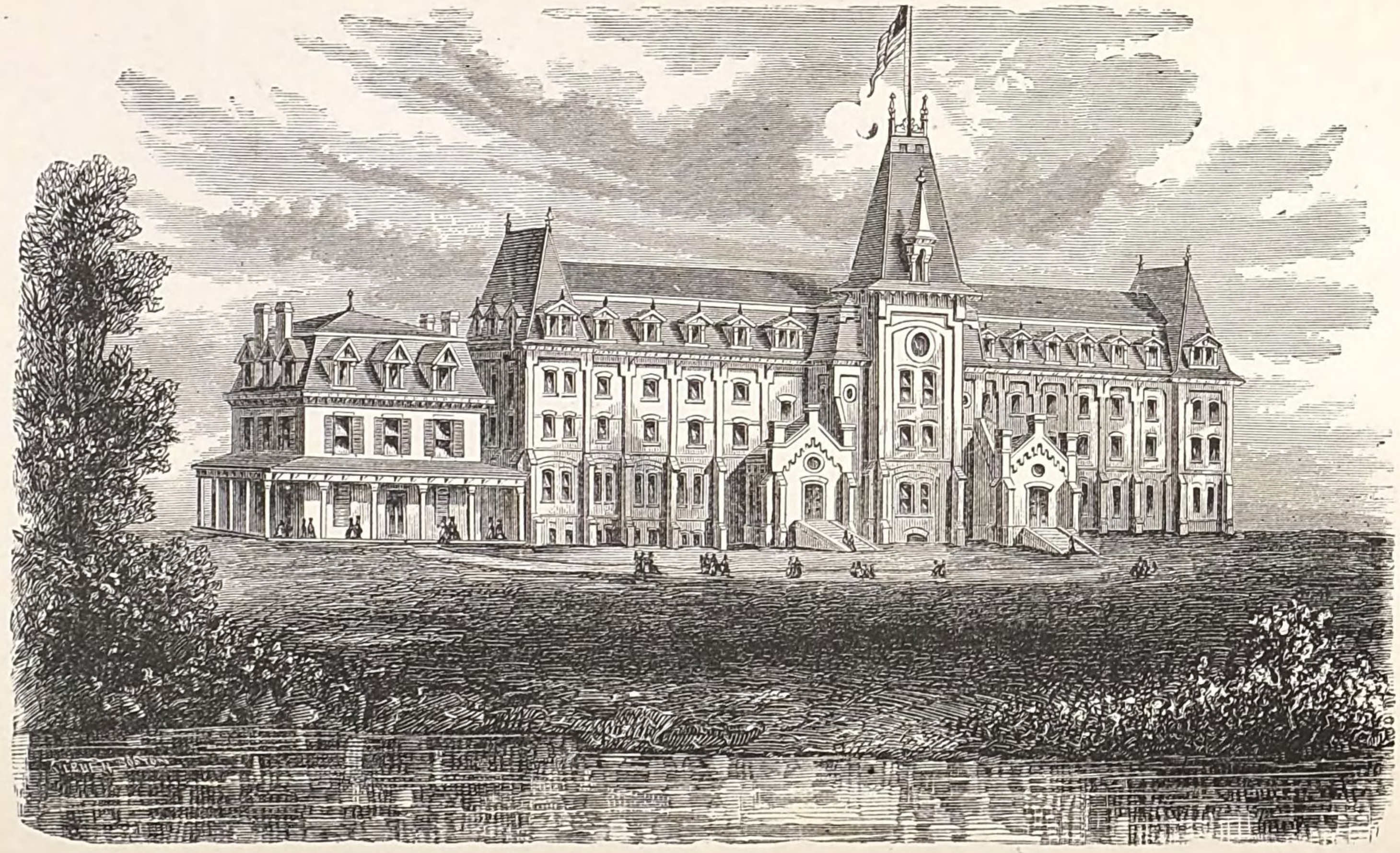
HAMPTON NORMAL AND AGRICULTURAL INSTITUTE.

EXPLANATION OF THE ACCOMPANYING DIAGRAM.

1. Virginia Hall, 100 by 190 feet, built in 1877: seventy sleeping rooms, chapel, dining room to seat 300, kitchen, laundry, work rooms, shops.
2. Academic Hall, 110 by 75 feet, containing assembly and recitation rooms, office, and attic dormitory.
3. Seniors' cottage, 32 by 60 feet, 30 students.
4. Maple Cottage, 25 by 32 feet, 18 students.
5. Chapel.
6. Principal's residence.
7. Treasurer's residence.
8. Fire department.
9. Residence of farmer and of pastor.
10. Lexington Cottage.
11. Engineer's cottage.
12. Base ball grounds.
13. Hot beds.
14. Barn.
15. Indian girls' building, "Winona Lodge."
16. Raby Lodge.
17. Ex-President Tyler's house.
18. Rev. Mr. Tolman's residence.
19. Indian boys building, "Wigwam."
20. Office and library building.
21. Stone Memorial Building.
22. Students' dormitory.
23. Old workshop.
24. Huntington Industrial Works—saw mill, &c.
25. Machine shop.
26. Indian workshop.
27. Woodbine Cottage.
28. Rose Cottage.
29. ———.
30. Soldiers' monument.
31. Peach orchard, 700 trees.
32. Cherry orchard, 400 trees.
33. Standard pears, 250 trees.
34. Dwarf pear orchard, 400 trees.
35. Grape vines.
36. Nurseries.
37. Apple orchard, 500 trees.
38. Normal school cemetery.
39. Strawberries.
40. The "Marquand" dormitory.


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National Cemetery
31
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Old Ship Yard
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24
Hampton River

S. EX. 26., 2, 47.



HAMPTON INSTITUTE—VIRGINIA HALL.

[S. Ex. 25.—face p. 237.]

HAMPTON NORMAL AND AGRICULTURAL INSTITUTE.

[Statement made October, 1882.]

The Hampton Normal and Agricultural Institute was founded for the instruction of colored youth of both sexes in agriculture and the mechanic arts, and their preparation for the work of teaching among their own race. It has more recently extended its work to the teaching and training of Indian youth. The intention is not to develop the mind of its pupils by collegiate studies, but rather to build up in them a substantial character and habits tending to prosperity. This is done by combining a course of English studies with drill in intelligent manual labor, instructive of itself, promotive of self-reliance and manliness, and helpful to the poor and aspiring negro. The coeducation of the sexes is expected to give the scholars just and appropriate views of their mutual relations. The influence of the school is extended to the masses of the colored people through its graduates, who carry its teachings to the youth of all sections and perform their work with ability and success.

The school is chiefly supported by voluntary contributions from northern friends. It also receives one-third of Virginia's share of the agricultural land grant from the general government. Its sources of revenue are, first, income of agricultural college fund, about $10,000; second, income of school endownment, about $3,500; third, voluntary contributions, about $30,000.

The value of the farms, school grounds, and buildings is $349.283.81; of stock and furniture, $71,080.25; of invested securities, $67,208.46.

The annual expenditure, not including outlays for buildings or cost of 100 Indian students, is $45,000, of which the salaries of officers and teachers is $30,000.

The teachers are as follows: Moral science and agriculture, 1; book-keeping and commercial law, 1; political economy and civil government, 1; mathematics (arithmetic and algebra), 3; English literature and language lessons, 1; grammar and composition, 1; reading and elocution, 1; writing and spelling, 3; history, 1; geography, 1; physiology and hygiene, 1; natural philosophy and chemistry, 1; music, 1; practice-teaching, 1; night school for work students, 5; Indian classes, 8. Industrial teachers, 25; viz, farming, wheelwrighting and blacksmithing, 3; saw-mill and wood-working, 5; engineering, machine shop and knitting room, 1; printing, 1; shoe-making, 1; Indian work shop: instruction in carpentry, painting, tinning, harness making and general repairs, 1, with five assistant teachers; young women's industrial department: sewing and tailoring, 3; cookery, 1; household work, 3.

The enrollment for the school year ending June, 1882, was as follows: colored young men, 239; colored young women, 173; Indian boys, 61; Indian girls, 28; total 501. Average age of young women, 18½ years; average age of young men, 20 years. There was a gain of 106 colored students over the previous year, chiefly among the boarders.

No charge is made for tuition. Board is charged at $10 per month, of which an average of two-thirds is paid in work. Tuition is met by contributions of scholarships from the North.

Scholarships are of two kinds, viz: 1. Permanent, $1,500 each, of which there are thirty-five. 2. Annual, $70 each, of which there are an average of one hundred and eighty, not including those for Indians.

Up to this time, October 23, 1882, 1,886 have been admitted; some of them remained but a few weeks. Including the class of 1882, 456 have graduated. Of these, 23 have died. Not less than 90 per cent. of graduates have devoted themselves to the work of teaching their people. About one-third of the graduates are girls. The proportion of girls in the school is increasing.

The principal said in his report for 1880: "The testimony of southern educational men to the success of our graduates since 1870 has been all that we could wish. They are now in greater demand than ever for the charge of the free colored schools of this and other States; over 20 more than we could supply having been called for this year. From 10,000 to 20,000 children have been taught by them the past year. The majority of them are in the country, with salaries of from $25 to $30 a month, for five or six months, which have of late been paid with promptness. During the off months the industrial training received here gives them resources which they find indispensable." The demand has increased and the applications continue to exceed the supply.

The course of study is as follows:

Junior year: Reading, penmanship and spelling, mental and written arithmetic, geography and map drawing, grammar, and United States history. Instruction in practical farming and the mechanic arts commenced and continued throughout the course, from a day and a half to two days each week. Instruction in sewing and household industries commenced and continued throughout the course, employing the girls from a day

and a half to two days each week. Bible lessons commenced and continued throughout the course, on Sunday afternoon from 2 to 3 o'clock.

Middle year: Reading and elocution, penmanship and spelling, arithmetic, grammar, composition and rhetoric, United States history, moral science, physiology, natural philosophy, vocal training. Industrial training as before specified.

Senior year.—Reading, English literature and composition, algebra, book keeping, ancient history, political economy and civil government, theory of agriculture and chemistry, with laboratory work, lectures on Dr. Hopkins's Outline Study of Man, art of teaching. Daily lessons are given to the senior class in the theory and methods of teaching. Members of the class visit the Butler school (a primary school taught on the grounds, and partly sustained by the county as a public free school) for purposes of observation and practice.

A three weeks' institute at the close of the course gives also special preparation for teaching.

A fifteen minutes' talk is given daily to the whole school upon the news of the day, &c.

The studies of the Indian classes are rudimentary; teaching is chiefly by the object method. At the close of the school year of 1880, after little over eighteen months' tuition, they were reading simple stories. The girls have the same educational advantages as the boys and are in the same classes. They are also taught sewing and housework by their matron, and share the instructions of the cookery class with the colored girls.

Those of the Indian students who have sufficient knowledge of English enter the regular classes of the school. Three Indian young men graduated very creditably with the class of 1882; another is doing well in the class of 1883; and over a dozen are in the two lower classes—boys and girls.

OPPORTUNITIES FOR INDUSTRIAL EDUCATION.

The students pay about two-thirds of the charges made against them, by manual labor. The value of the work done is not so great as would be that of regular common laborers hired at the usual rates. A loss of from 20 to 40 per cent. is entailed. This expense is warranted by the good which is done in the training of the pupils. The question is rather what can be done for the student than what he can do for the institution. Able bodied farm boys get 8 cents an hour; wages are according to work done.

The following extract from the principal's report for 1882 gives the prominent present and prospective industrial employments of the school:

INDUSTRIAL DEPARTMENTS.

Work details, colored students.

Housework	175	Cookery class	60
Industrial room	65	Laundry	110

No work has yet been provided for day scholars. A girl often works in two departments.

Farm	65	Industrial room	1
Saw-mill	38	Tinsmith	1
Knitting room	7	Painters	2
Engineer's department	9	Cooks	3
Table waiters	35	Carpenters	4
Janitors	12	Shoemakers	3
Office duty	4	Tailor	1
General duty	3	Mail-carriers	2
Blacksmith	1	Wheelwrights	3
Printing office	3	Stock farm	10
Commissary department	1	Brickmakers	4
Watchmen	2	Harness-makers	2

Day scholars on orderly duty, 13. Total earnings last year, $24,898.37.

Indian students.

Housework	15	Industrial room	28
Cookery class	20	Wheelwrights	4
Farmers	8	Painters	2
Carpenters	41	Engineers	5
Shoemakers	11	Butchers	2
Tinsmiths	7	Harness-makers	4
Blacksmiths	3	Printers	2

Indians have a monthly allowance of from $2.50 to $5.00 for their labor, according to the time and value of it. It is not included in the above total; with this they purchase a portion of their clothing. This is to teach them the use of money. As a rule they work half days, studying the other half, and have holiday on Saturdays.

Indian apprentices are slow, and, owing to ailments, not very regular; but they are neat, interested in their work, and learn easily.

AGRICULTURE AND MECHANICS.

The number of colored students employed in agriculture was 83; earnings last year, $6,025—to be increased this year.

This department has two farms, one of 190 acres, connected with the school, and another 4½ miles distant, of 350 acres, called "Hemenway Farm" a gift, to which has recently been added, by purchase, another of 250 acres adjoining; both are well adapted for stock and grain.

The last named, of 600 acres, is in charge of Mr. Charles H. Vanison, a graduate, and is cultivated entirely by work students. On the former, Mr. George Davis, also a graduate, assists Mr. Howe, the general manager.

Agriculturally the school is well appointed; nearly complete, with land, outfit, machinery, and stock. There remains only a debt of $2,500 on the last purchased farm, half its cost. Brick-making and the wheelwright and blacksmith shops are in this department.

Total number of colored students employed in mechanics 82; number of Indians employed, 61.

THE HUNTINGTON INDUSTRIAL WORKS,

comprising a steam saw-mill and wood-working establishment, were the gift of Mr. C. B. Huntington, of New York, costing in all over $30,000, and affording to industrious young men without means the opportunity of getting an education and learning a good trade.

Colored students employed	38
Earned last year	$3,535

Earnings will be increased this year. The capacity of the mill per day is fifteen thousand feet of lumber. Every year a class of from fifteen to twenty destitute, ignorant, but earnest young men, enter the mill for one year steady work of ten hours. Of the most promising, a few are selected for a two years' apprenticeship in the wood-working shop in the second story. They are "work students," studying two hours every night till they enter the regular course, and then are employed two days each week, studying four days throughout the three years' course, being able to save from one year of steady work at the mill $60 to $70 and in two years $140 for school expenses. They are the poorest class, but ask no charity.

About one-fourth drop out for various reasons. Those who graduate are valuable men. The mill is doing a good business, preparing and selling building material of all kinds. It creates fine opportunities for young men to work their way, and may well be a source of gratification to its generous founder.

ENGINEERING.

Number of students employed	13
Earned last year	$1,130 74

and increasing. This branch has been established eight years, but has never had suitable quarters. It has piped all the principal buildings for steam, water, and gas, connecting them by an underground system of steam pipes 1,500 feet in length, which works admirably; made 300 bedsteads out of gas pipe; attends to ten boilers and four steam engines, and repairs machinery.

A gentleman has just offered $4,000 for a new brick workshop 60 by 40 feet, two stories, in which a bone mill and grist mill can be placed to great advantage.

We have long ground bones, but never satisfactorily, owing to poor machinery, and could save about $35 a month by grinding our own meal.

Considering the probable growth of the shop, a suitable steam engine, boiler, lathes of various kinds, shafting, pulleys, drill press, planer, grist mill, and bone mill would cost $10,000.

Such a machine shop would add to the educational powers of the institute and provide much-needed opportunities.

GENERAL STATEMENTS.

Agriculturally the negro is going ahead, for he is the laborer of the South; he is buying farms at $5 an acre, and covering the land with his small holdings.

Mechanically he is losing ground, for there is no way for him to acquire the needed skill. The majority, however, are not adapted to mechanics. For all that, they are capable of producing an excellent mechanical class. The shops, North and South, are, as a rule, closed to them.

The present generation of colored mechanics were nearly all trained in slavery.

In general, it may be said of the industries of schools which teach the trades in connection with studies, that, if given the building and outfit and salaries of foremen, they will take care of themselves.

Our problem is to turn to account the labor payments of students, who, last year, earned $24,898.37, being paid at the rate of from 4 to 8 cents per hour. This year it will be more.

From their standpoint it is fairly earned. From ours, at least one-fourth of it, say $6,000, is a direct drain on our resources. We give much employment regardless of pecuniary profit; the welfare of the student is made paramount; instruction is primary to production. The student learns, but the school loses.

This $6,000 must be had to pay for board and clothing. Shall it be received as a charity or a wage-money? The difference is wide. We choose the latter, though it would be easier to get it by an appeal to the benevolent in the name of poverty. We ask the benevolent to maintain a work that within itself takes care of the student and develops self-reliance and manual skill, and preserves his self-respect and dignity.

This is not the way to make polished scholars, but it makes men.

Last year's total charges to students (for board, &c.,) were	$30,679 96
Last year's payments by students:	
In labor	24,898 37
In cash	4,025 37
Aid in direct charity	2,159 29
Total	31,083 03

The surplus of students' credits is owing to the fact that the ninety work students who attend night class only, working the whole of every week day, are laying up their earnings by agreement, so as to have a fund from which to meet their cash payments when they enter the regular course. As students have increased, charity has decreased, as follows:

Session of 1878–'79, 254 students; direct aid	$2,452 19
Session of 1879–'80, 293 students; direct aid	2,491 04
Session of 1880–'81, 321 students; direct aid	2,159 29

Average students' labor is not up to that of outside labor. The student's chief ambition is for book knowledge. He works because he must; his muscles are not tough; life is not fully serious to him, for all its responsibilities are not upon him. There is a humanity in the school that he may unconsciously count on.

Many, however, either flinch from work or break down under it. The way to make men is to train the head and the hand together. This is the most difficult, the most costly problem in education, but it pays. The better the product the more it costs.

RESULTS OF INDIAN EDUCATION.

Our Indian workshop has completed, for the Indian Department in Washington, to be used in the West, 2,000 pairs of shoes, 70 sets of double plow harness, and 500 dozen articles of tinware, and hopes to supply something more.

The interesting fact of the year has been the return, after three years' training, of thirty-one Indians—five of them girls—to their homes in Dakota. One went to Indian Territory.

They were brought here by Capt. R. H. Pratt, in November, 1878, by order of Secretary Schurz, and returned October 1, 1881.

They are employed at salaries of from fifteen to twenty dollars a month and rations, as follows: Farmers and herders, 7; teachers, 3; carpenters, 9; blacksmiths, 2; office boy, 1; issue clerk (for rations), 1; shoemaker, 1.

One is out of health and one was killed by accident.

They are settled among the Sioux agencies on the Upper Missouri, thus: At Yankton agency, six—four boys and two girls. These are favorably reported upon by the Rev. J. P. Williamson and Rev. Joseph Cook, missionaries. The former says:

"So far they have all run well. I have not heard a slander against one of the number.

They attend church regularly; they are recognized as leading spirits among the Christian youth; their appearance is always creditable." He says: "Not one white boy in sixteen would do his work or teach as well as David Simmons."

The latter writes less favorably of the two girls, who live in the camp with their mothers.

Five are at Lower Brûlé, of whom three had not been doing well. Major Parkhurst, agent, has just written as follows:

"All the returned boys from Hampton have come to time, and are now at work. They were 'tired of doing nothing,' and concluded 'to come under the yoke.'"

Three boys and one girl are at Crow Creek, the latter keeping her father's store and accounts, but not under the best of influences. The two shopboys, carpenters, are reported as "doing all that could be expected," and the teacher as "doing splendidly." They are exerting a good influence on the Indians around them.

Five boys are at Cheyenne River Agency. One is an assistant teacher; the rest are mechanics. "All are doing splendidly," reports Major Love, agent. Mr. Kinney, missionary, writes, "Your boys are doing very nicely."

Two boys and one girl are at Standing Rock Agency. Major McLaughlin, agent, writes: "Both the young men are doing well." A lady missionary reports that "The young men are doing first rate; they are quite conscientious workers, and have the respect of every one." The girl has poor prospects.

Five boys and one girl are at Fort Berthold Agency. The girl writes: "Hard out here to be good woman." She is doing well, however. Three of the boys give good satisfaction as workers; two have gone to school at Santee.

The latest reports upon them are the most hopeful. Those who have separated themselves from camp-life, and occupy decent rooms at the agencies, have done the best. Girls cannot do this, and suffer in consequence. Forty new pupils from the same agencies are here, and will, we hope, in two and one-half years re-enforce them. Will they hold out? Their relations with the school are most pleasant; there is constant correspondence, and we hope to help them, even from here. A probation of six months is short, and not conclusive, but it gives ground for hope.

The new Indian girls' building, to which the name "Winona (Elder Sister) Lodge" has been given, is finished, and has cost $30,000. Probably it is the most complete provision ever made for such a purpose. Our thirty Indian girls will be increased to at least fifty next fall.

S. C. ARMSTRONG, *Principal.*

The following article from the American Missionary by the principal of Hampton Institute, General S. C. Armstrong, gives a brief and comprehensive view of the work and duty of Indian education in the east:

At Hampton there are ninety and at Carlisle there are nearly three hundred Indians—boys and girls—who are learning civilization as an object lesson, and are themselves an object lesson to the centres of intelligence and wealth, where are the sentiment that inspires and the means that provide for the combined practical and spiritual teaching of the red man. They suffice, perhaps, for a tangible proof of the Indian's capacity, of which the need was great; their effect upon public sentiment has been marked. The result with these Indians has, so far, proved satisfactory. Scattering these pupils among the farmers of Massachusetts and of Pennsylvania for a portion of the year has had such a good effect mutually that five hundred more might well be so placed in various States, under the care of special agents, with proper rendezvous where the sick or unsatisfactory might be kept with a view to returning home, say, 10 per cent. of the entire number.

The negro institutions at Nashville, Tenn., at Talladega, Ala., and elsewhere could do excellent work for them. The aims and methods of most white schools render them unfit for Indians.

We have found the weak point of the race to be physical, not mental or moral. They can endure the hardships peculiar to the plains, but not steady work from day to day. They are tainted with inherited disease; the lungs are their weak point. They are sinewy but not muscular; however, as a race they hold their own with favorable surroundings, are not decreasing seriously, if at all, and will not settle the problem by dying out.

Mechanically they have proved apt to learn, but slow to execute. Our Hampton Indian workshops have this year supplied the Indian department with two thousand pairs of men's brogan shoes, five hundred dozen articles of tinware, and seventy-five sets of double plow harness, which were pronounced by the inspectors well made and satisfactory. Carlisle has done more.

Both girls and boys take quickly and kindly to neatness and to industrial pursuits, as well as to books. They are as eager as the negroes for knowledge, and become more and

more so as they advance. Want of ambition is the least of their troubles. Teaching them is hard work, but interesting and stimulating in the highest degree.

They resent injury, but are not revengeful; not a sign of treachery in nearly five years. Religiously they are, I believe, the most hopeful of the heathen races. The vastness and the grandeur of the West has affected them as desert life has the Arabs; they are remarkably oriental in customs and ideas. They worship no fetish, there are no idols to break, but they have a crude faith to be cleared, dim eyes to be opened.

Christian efforts, under the care of Archdeacon Kirby of the Episcopal Church, have evangelized ten thousand Indians of British America, in their simple natural life. The mixed, harassed condition of our own makes the work far more difficult.

The mingling of races at Hampton has worked well; they are mutually helpful and stimulating. An Indian classmate is kindly, thoughtfully treated by his colored compeers. A race that has been led is leading another. The "house-father," chief of our sixty Sioux boys, is a negro. With perhaps finer mental and moral texture, the red race does not produce half enough to feed itself; the rougher, stronger blacks have not thrown a pauper upon the country, and raise raw material for the mills of Christendom. With benevolent intentions we have diminished and weakened the one; using the other only for selfish purposes, it has multiplied and grown stronger. Bringing both races under the care of the American Missionary Association is most fitting and wise. Both are peculiarly the concern of the American people, are providentially committed to our care, and are a part of us. In doing for them we are doing for ourselves, our children, and our country.

On the Indian girl rests most heavily the weight of past and present influences. When, in October, 1881, I took 25 Indian boys and five girls back to their Dakota homes, after three years' training at Hampton, the former were readily placed in rooms by themselves, away from the camp, employed in agency workshops at the trades they had learned, and thus helped on greatly. The girls could not be so isolated; they had no trades, and though they could make their own garments and do housework, there were not suitable situations for them; they returned to their mothers and grandmothers, who might sell them to the brave who would pay the highest price in ponies for them.

One of the five, an earnest Christian, wrote: "Hard to be good woman out here." She finally married a white man of good repute. Another is reported as a most satisfactory house servant in the family of a missionary; another keeps her father's store and books. He is one of the best and most thrifty of Indians; but the family live in one room in a log house. Two others, younger, are waiting an opportunity to return to Hampton for two years' more training, with a view to becoming teachers.

Teaching is the career for Indian girls, as it has been the one way for colored girls of the South to be more than drudges; there it is the only field for a womanly ambition. The increase of educational work for Indians creates some hope for their girls, on whom rests the future of their race.

There is a tendency to increase our Indian's course of study to longer than three years. One set having returned, the Indians, whose parental feelings are tender and strong, are more trustful of us, and readily consent to a longer absence of their children. One boy has already returned at his own expense, and another is saving his money for the purpose, both to learn more and to perfect themselves in their trade of shoemaking. The sooner the Indian can stand without government aid the better. Any boy can return who will pay his way back. This gives a motive to work, and creates appreciation of his opportunities.

For the practical necessities of Indian life their training should be practical.

We give half the day to study and half to labor. An education which does not fit them to take care of themselves may do them more harm than good.

I think that when charity and the government are linked together for Indian work the former should erect the buildings and maintain the teachers, the latter supply the wants of the body. United States beef and flour and shoes are as good as anybody's, but government employés, as our civil service stands, are not the men to elevate the Indian. The telling factor in all work for men is the person who does it. Unless that shall be supplied from the pure fountains of our Christian civilization it will not, as a rule, be supplied at all. I refer to the educational work at the agencies; there the government day and boarding schools should be strictly responsible to the controlling power, and their moral value will be that of the agent in charge. Missionary institutions should stimulate these, and should be conducted by superior men and women directly responsible to their Eastern supporters. I call it sham missionary work to send out Christian teachers to be supported on public pay. The churches who do that, and some do, are doing nothing. Let us first send our own teachers for the Indians, and then fit them to become their own teachers; to make the teachers is to make the people.

The free negro schools in the South are vitalized by a number of strong central institutions under northern men that train the picked growth of the race as teachers. This

is, I think, the true relation of eastern charity to the Indian. There should be an excellent boarding and industrial school at each important agency for this purpose. Getting $15 a month of Government for food and clothing for each pupil need not in the least weaken the independence or morals of teachers. The friends of the Indian will do the rest. The situation is critical, the opportunity is great; the rising tide of public sentiment, the movement at Washington, the eagerness as well as the exigency of the red man mean much.

But this work needs a leader; it will drag if thrown on an overloaded man. The man is as much as the money; the one will bring the other, both by wise appeals and good work that will commend itself to the country. For more than a century Indians rejected our civilization; now their thinking men—for they are a race of thinkers—forecast the future and wish their children taught the white man's way as their only hope. They do not choose this; they are compelled to it. Hundreds, thousands, are waiting for an education. They beg for what they once refused.

RESULTS ATTAINED AT HAMPTON.

But the work of Hampton Institute is more largely with the colored people, and there need be no better evidence of the thorough and practical education they are there receiving than the report of the last examining committee and large percentage (61.4) of correct answers to questions submitted to the last senior class by Mr. George A. Walton, one of the committee. Portions of the report are here presented, together with a list of the questions mentioned:

Connected with the Normal Institute is the Butler school, which serves as a training or practice school for the students of the Normal. This school is in charge of the teacher of methods in the institute, and affords a fine opportunity for training in the art of teaching. There each student spends a portion of his senior year, not simply in observing, but in acquiring skill by the practice of his art. A "kitchen garden," as it is called, has been introduced into this school; this consists of practice in the various duties belonging to housekeeping, such as sweeping, dusting, laying and tending table, washing, and so on. These operations are practiced under direction of the teacher, by all the pupils, sets of miniature utensils being furnished for the practice. Thus the ordinary exercises of the school are supplemented by training in those habits of order and neatness so conducive to comfort, culture, and happiness in the home. Thus furnished, the student of Hampton graduates with an outfit which must place him in the front rank of the teaching profession in the section of the country where he is called to labor.

Nor does this growth cease with his graduation. By a plan, so far as known to the committee, peculiar to Hampton, the former graduates of the school take the principal parts at commencement; six of the exercises of this year were by graduates of the class of 1881, one was by a graduate of the class of 1873. For practical wisdom and breadth of comprehension, these parts could nowhere be excelled by any class of students of equal opportunities. All were delivered with force and expression, and must have convinced the most skeptical that the problem of the future of his race is solved when the colored man is furnished with an education and an equal chance to labor. Less time than we desired was given to examining the methods and estimating the results of the industrial education, which is a leading feature of the Hampton Institute. Enough, however, was seen to show that manual labor, as a means of mental and physical training, is an essential. Each student is required to give at least two days a week to this department. Some are engaged in working upon the land, of which there are about 600 acres of tillage; others work at the various trades. The students make long days, but with the varied employments, little fatigue is experienced, and good health is the rule. Thus, in addition to the knowledge and discipline received in the school proper, every student leaves the institution with the ability to support himself by some useful employment.

The industrial pursuits are calculated to exercise the students' active powers or faculties, as distinguished from their passive powers or capacities. In this respect these pursuits supplement in a remarkable degree the training received by the ordinary school processes. The complaint frequently made that the student is unable to do anything when he leaves school, is too often true; with such training as is received at Hampton this complaint is not likely to be made, for it will not be true. This would be inferred from the nature of the case, but it is actually shown in the service the graduates are able to render. The treasurer's clerks are graduates of Hampton, doing their work with accuracy and dispatch; the overseers on both the farms run by the institution are graduates of the school, as is also the head of the tailoring department. Over 90 per cent. of all the graduates have taught in the schools of Virginia or other States. One is principal of a normal school in Alabama, while three-fourths of all the graduates have chosen teaching as a profession. Others, not in schools, are filling positions of trust and respon-

sibility; nearly all who teach report Sunday schools connected with their day schools, and some have founded temperance societies.

Thus it will be seen that, wherever they go, the graduate teachers become the leaders among their people.

And so, through this and similar institutions throughout the South, the problem of good citizenship presented by negro suffrage is solved. Give the colored man a good education and a fair chance and he will surely become a good citizen and win for himself and his race honorable distinction. The figures in this problem are the slaves themselves; the solution depends on liberal endowments and efficiency of management, such as is seen at Hampton.

Though the colored race has been chiefly considered in the report and though the evidence is less cumulative in the case of the Indian, from what is known there is every reason to believe that, admitted to equal privileges and charged with the same responsibilities, the same results are to flow to the red man. The committee heartily concur in the statement in General Armstrong's report for the academic year just closed: "Our four years' work for Indians satisfies us that their progress is a question not of capabilities, but of opportunities. Universal education means peace and prosperity to the red man. Justice and humanity call for it, and common sense suggests that paying $800 in three years for the education of an Indian is better than paying $1,000 a year for each soldier sent to fight him."

So the question what shall be done with the emancipated slave and the "savage Indian" is solved not by extermination, but by mental discipline and a training of their powers to various forms of labor.

QUESTIONS.

I.

ARITHMETIC.—How many bushels of potatoes in a rectangular bin 10 feet square at the bottom and $2\frac{1}{2}$ feet deep, allowing $1\frac{1}{4}$ cubic feet to a bushel?

LANGUAGE.—Write a telegram to some person at home, stating that you have arrived at New York and naming the day you expect to reach home; also naming the railroad by which you are to come.

GEOGRAPHY.—(1) Name some country in about the same latitude as New England, which has a warmer climate. (2) What are some of the causes that affect the climate of a country?

II.

ARITHMETIC.—Two bushels one peck of seed peas were put up in bags, each holding three-fifths of a gill; how many bags were required?

LANGUAGE.—Correct the following sentence, if incorrect, and state the reason for the corrections:

Samuel or John have worked here last year; i do not know as either of them are here now.

GEOGRAPHY.—Name a port to which vessels sailing from Boston go for (1) sugar and molasses, (2) raw hides, (3) coffee. (4) Write anything you know about any of these articles.

III.

ARITHMETIC.—A square lot of land was inclosed by a fence at a cost of $40. If the fence cost $\$0.62\frac{1}{2}$ per rod, what was the length of one side of the lot?

LANGUAGE.—Correct the following sentence, if incorrect, and parse "laid" and "by:"

A peck of these kind of peas were laid by for planting.

GEOGRAPHY.—Name the bodies of water upon which are situated (1) Boston, (2) Springfield, Mass., (3) Philadelphia, (4) Chicago. (5) Describe any of these cities.

IV.

ARITHMETIC.—How many yards of carpeting three-fourths of a yard wide are required to carpet a floor $16\frac{1}{2}$ feet long and 9 feet wide, allowing nothing for waste?

LANGUAGE—Correct the following sentences, if incorrect, and parse "ought:"

Ought a pupil to whisper in school i don't think they had.

GEOGRAPHY.—(1) Name three important exports of the Southern States. (2) Tell where they are produced and anything you know about any of them.

V.

ARITHMETIC.—How many cans, each holding $1\frac{1}{5}$ pints, will be required to hold 7 gallons 2 quarts of preserves?

LANGUAGE.—(1) What is the subject of a sentence? (2) Give an example of a simple sentence; (3) of a compound sentence; (4) of a complex sentence.

GEOGRAPHY.—(1) Name five of the largest rivers of North America, and tell into what each flows. (2) State anything you know about any of these rivers.

VI.

ARITHMETIC.—If 2 boys can shovel a snow-path in 24 minutes, in what part of an hour can 3 boys shovel it?

LANGUAGE.—Write a short letter to your father, describing your school and your work.

GEOGRAPHY.—(1) Which is farther north, Albany or Paris? (2) Name in order the bodies of water you would pass through in going from Albany to Liverpool. (3) Describe any of the above named cities.

VII.

ARITHMETIC.—Find the bank discount on $600 from July 15 to the 5th of August next following, the rate being 5 per cent.

LANGUAGE.—Write a letter to a manufacturer, ordering goods sent you by some particular express.

GEOGRAPHY.—(1) Through what zone does the equator pass? (2) How many degrees in width is this zone? (3) What countries lie mainly in this zone?

VIII.

ARITHMETIC.—Bricks are 8 inches long, 4 inches wide, and 2 inches thick. How many bricks will it take to build a wall 20 feet long, 10 feet high, and 18 inches thick, allowing one-fifth of the wall to be cement?

LANGUAGE.—Correct the following sentence, if incorrect: (1) Each board of officers keep their own accounts. (2) Make out a bill against your teacher for a hat, and receipt the bill.

GEOGRAPHY.—(1) Draw an outline map of your own State, and locate your own town. (2) Write a brief description of your town, naming in order the towns which surround it.

WEST VIRGINIA.

WEST VIRGINIA UNIVERSITY, MORGANTOWN.

[Statement obtained from catalogues, &c.]

The proceeds of the land grant to West Virginia were supplemented by appropriations from the State and aid given by the town in which the agricultural college was to be located. The original institution was named the West Virginia Agricultural College, but after it had been fully adopted by the State an act was passed requiring it to be known as the West Virginia University. It is announced that its design is "to educate, inform, and discipline the student's mind, to strengthen his moral principles, and supply such general and generous as well as special culture as will best prepare him for success and usefulness in any pursuit or profession in life."

The value of its grounds, buildings, and apparatus is estimated at $175,000. Its productive funds amounted to $110,000, the annual income of which is $6,500. The State appropriation for 1881 was $16,500.

The faculty has 12 members. The department of agriculture, chemistry, and physics has been recently furnished with a commodious and well appointed laboratory of theoretical and practical chemistry.

The students in attendance in the school year 1881–'82 were 177 in all the departments. Of these 102 were preparatory and 75 collegiate students. Nearly all of them were residents of West Virginia, only 18 being from other States. The tuition in the preparatory departments is $5 each term, and in other departments $8. There are three terms a year. The number of graduates previous to 1883 was 78.

The instruction thus far provided for in the university is embraced in 5 departments, namely: classical, scientific, agricultural, engineering, and military; there are also law, medical, and preparatory departments. The classical course is similar to the academic course of other colleges. The scientific course gives special prominence to chemistry, and agriculture is among the studies prescribed. The department of engineering has the studies common to such a course, being the same as the scientific course up to the senior year. In the military department there are daily drills by the cadets, and military science is systematically taught. The studies include among others cavalry and artillery

tactics, military history, military engineering, the strategy and art of war, military law and court-martial, and ordnance and gunnery. Dress parade, reviews, inspections, and guard mountings are held as often as deemed expedient. The law provides that five cadets may be appointed in each senatorial district in the State. These are educated free of cost for tuition, books, stationery, &c. The cadets may pursue their studies in any department of the university, subject to general regulations. The drill occupies one hour on each of four days in the week. The cadets must be between sixteen and twenty-one years of age.

The studies of the agricultural department are embraced in a two years' course, and those who complete them creditably receive a certificate to that effect. Agricultural instruction is given largely by lectures. The subjects treated by these in the first year include the chemistry, structure, and physiology of plants, air, water, and soil; tillage, draining, and manuring; domestic animals; foods; agriculture; products; gardening and the culture of fruits and vegetables. In the second year topics directly treating of farm operations, including the raising of crops, the care of domestic animals, rural economy, the history of agriculture, and entomology are made the subjects of lectures. The law department includes courses for two years of nine months each, and leads to the degree of bachelor of law. The medical department is also open during the entire university session of nine months. In the two departments last named instruction is given principally by means of lectures and practical exercises by the students.

WISCONSIN.

UNIVERSITY OF WISCONSIN, MADISON.

[Statement obtained from catalogues, letters, &c.]

The University of Wisconsin was organized in 1848, and reorganized in 1866. By the act of reorganization its object was declared to be "to provide the means of acquiring a thorough knowledge of the various branches of learning connected with scientific, industrial, and professional pursuits."

The endowment consists of the university fund, $226,460.78; the agricultural college fund, $267,330.86; the Johnson endowment fund, $5,000; and the Lewis medal fund, $200. The value of the grounds, buildings, and apparatus is $455,000. For the year closing with September, 1881, the income was as follows: State appropriation, $44,558.27; from productive funds, $31,749.38; students, $5,933.43; entire income, $82,669.81. There are 4,210 acres of university land and 4,359 acres of agricultural college land remaining unsold.

The faculty consists of a president, 19 professors of the colleges of arts and letters, 7 professors of the law faculty, 11 instructors, and 5 other officers.

The collegiate professorships are as follows: Mental and moral philosophy; mathematics; Latin and history; Latin; Greek language and literature; astronomy; civil polity and political economy; physics; chemistry and agriculture; German language and literature; English literature; geology; mining; metallurgy; Scandinavian languages; rhetoric and oratory; French language and literature; zoölogy; civil and mechanical engineering; botany and agriculture; music; military science and tactics.

The number of students in attendance during the collegiate year closing in 1882 was 398, classified as follows:

	Seniors.	Juniors.	Sophomores.	Freshmen.	Total.
Resident graduate	.....	.....	.....	.....	1
Ancient classical course	18	11	19	18	66
Modern classical course	16	18	15	22	71
Scientific course	20	9	8	24	61
Civil engineering course	3	5	11	.....	19
Mechanical engineering course	.....	2	.....	.....	2
Metallurgical course	3	.....	.....	.....	3
Agricultural course	.....	1	.....	2	3
Total	.....	.....	.....	.....	228
Special students	.....	.....	.....	.....	116
Law students	.....	.....	.....	.....	50
Greek class	.....	.....	.....	.....	6
Grand total	.....	.....	.....	.....	398

There is preparatory work in Greek only.

Tuition is free to residents of the State; $18 to others.

There are ten scholarships, for the present limited to students speaking one of the Scandinavian languages. Their annual value is $50 each.

The graduates number 877; collegiate, 570; law, 307. Of the collegiate graduates 430 are men; 140 women.

Degrees have been conferred as follows: A. B. (ancient classical course), 129—121 on men, 8 on women; L. B. (modern classical course), 66—33 on men, 33 on women; S. B., 228—160 on men, 68 on women; C. E. B., 21; M. B. (mining), 7; M. E. B. (mechanical engineering), 1; agriculture, 1.

The eight courses of study in the colleges of arts and letters are termed respectively the ancient classical, modern classical, general science, agricultural, civil engineering, mechanical engineering, mining, and metallurgical courses.

The ancient classical course corresponds to the usual academic course of other colleges.

The modern classical course substitutes French or German for Greek.

The general science course is, after the first year, chiefly elective, and election of studies may be made from all the leading departments of mathematical and physical science, and the modern languages.

The civil engineering course provides such instruction as shall fit its students to develop into capable engineers.

The mechanical engineering course is accompanied throughout by practice in the machine shop.

The mining and metallurgical courses are nearly alike, the variation being in giving special prominence to chemistry in the latter. The two courses may be united and accomplished by an able and diligent student in the usual time allotted to a single course.

The agricultural course is supplemented by experiments in agriculture and horticulture on the university farm.

The courses in agriculture and mechanical engineering deserve extended notice, as being the ones which most directly teach industries.

The course in mechanical engineering was established in 1877. The studies of the first year are the same as those in the course in general science, with one exception. The special studies of the second year are chemistry, drawing, and the elements of machines; the third year, drawing, resistance of materials, the steam engine and machinery, and mill work; the fourth year, drawing and the steam engine continued, metallurgy, hydraulics and hydraulic motors, and machine designing. Shop practice is continued throughout the course.

The course in agriculture, extending through four years, is designed to meet the wants of such young men as may desire a college education and yet have it tend in the direction of the farm,

One language is taught in this course, namely, German, by which the way is opened to a direct knowledge of the work of the agricultural experimental stations of Germany. In this course some eight terms in all are spent in the study of chemistry, and practice is given in analysis of agricultural products, both qualitatively and quantitatively. Next to chemistry stands botany, which is taught during four terms, and comprehends a study of not only our common plants but a familiarity with the wild and cultivated grasses, and as full a consideration as time will permit of the noxious fungi. Among studies requiring from one to two terms might be named zoölogy, physics, and geology. Agriculture as a study comes in the last year of the course, at a time when the student is well prepared by previous preparation to take up such subjects as stock breeding, stock feeding, rotation of crops, drainage, &c. Students completing the course are given the degree of bachelor of agriculture.

Since the requirements for admission into this course are above the ability of many young men who are desirous of devoting some time to study in this direction, special students in agriculture are admitted upon passing examination in the common English branches. Special students may pursue any studies of the course for which they are prepared.

It is most evident, however, that the scope of an agricultural department is quite limited if its effort ends with giving instruction to the pupils at hand. Cognizant of this fact, and desirous of extending its usefulness to the many intelligent farmers of the State who are otherwise ignored, the board of regents established the experimental farm. For a series of years the farm was largely devoted to making tests as to the productiveness of the various varieties of field crops. Among the experiments, running through several years, was that of the endeavor to find a winter wheat suited to Southern Wisconsin. The value of the Fultz and Clawson were early demonstrated for this purpose.

In 1881 the legislature appropriated $4,000 for experiments in amber cane and the ensilage of fodders. In 1882 it appropriated $2,000 for a continuance of this work. It is yet too early to predict the results of these experiments as a whole, but those of the first

year with amber cane were permanently successful as compared with results obtained in this direction elsewhere. In 1881 about 1,200 pounds of good raw sugar were made, and this was refined into good brown and white sugar. The yield per acre varied from 700 to 1,000 pounds of sugar, in addition to from 80 to 100 gallons of syrup and 30 bushels of seed.

In the ensilage of fodders no very satisfactory data were obtained, but at present it would seem that this season we have all the facts necessary to ascertain the value of this method of preserving fodder in our State.

The university is open to females under such regulations as the board of regents may deem proper. They are received in all respects on the same terms as young men.

The university is provided with extensive and valuable geological and mineralogical cabinets, and collections in natural history; also with well selected philosophical and chemical apparatus.

There are also chemical, zoölogical, physical, mineralogical, and assay laboratories, well supplied with apparatus and material, affording excellent facilities for the prosecution of studies in the several departments of science.

When the course in mechanical engineering was established, the work of fitting up a machine shop, in which instruction in practical mechanics and machine construction might be given as a supplement to that of the class room, was undertaken. A room 38 by 40 feet, 14 feet high, was set apart for the shop. Machinery and tools of the most approved kinds were procured. Among them were a planer, two engine lathes, a hand lathe, a milling machine, an upright drill, and a full complement of benches and bench tools. The motive power is furnished by a thirty horse power steam engine. Ten hours per week is required throughout the course.

The method of instruction is a combination of the Russian system with that followed at the Worcester (Mass.) Free Institute. Much practical work is done in the shop. One of the articles in process of construction in 1880 was an engine for the State Capitol.

Each student is required to construct the model of a machine previous to his graduation.

APPENDIX B.

STATISTICS OF INSTITUTIONS ENDOWED WITH THE NATIONAL LAND GRANT.

Name.	Location.	Date of charter.	Date of organization.	President.	Preparatory department.		
					Instructors.	Students.	
						Male.	Female.
State Agricultural and Mechanical College.	Auburn, Ala	1872	1872	Rev. I. T. Tichenor, D. D.	1	47	.....
Arkansas Industrial University.	Fayetteville, Ark	1871	1871	General D. H. Hill.....	*a*6	*a*321	
University of California...	Berkeley, Cal.....	1868	1869	William T. Reid, A. M.	0	0	0
State Agricultural College	Fort Collins, Colo.	1877	1879	Charles L. Ingersoll, M. SC.	.....	.....	.....
Sheffield Scientific School of Yale College.	New Haven, Conn	1701	1847	Rev. Noah Porter, D. D., LL. D	.....	.....	.....
Delaware College.....	Newark, Del.....	1867	1870	William H. Purnell, A. M., LL. D.	.....	.....	.....
State Agricultural College.*b*	....., Fla.....	.....	.....	.....	.....	.....	.....
University of Georgia:							
Georgia State College of Agriculture and Mechanic Arts.	Athens, Ga.....	1872	1872	Rev. P. H. Mell, D. D., LL. D. (ex officio).	.....	.....	.....
Southwest Georgia Agricultural College.	Cuthbert, Ga.....	1879	1879	V. T. Sanford, A. M.....	.....	130	.....
North Georgia Agricultural College.	Dahlonega, Ga.....	1871	1873	Hon. D. W. Lewis.....	2	129	
Middle Georgia Military and Agricultural College.	Milledgeville, Ga	.....	1880	W. S. Dudley, M. D	5	151	167
South Georgia Agricultural College.	Thomasville, Ga	1879	1879	O. D. Scott	.....	171	.....
Illinois Industrial University.	Urbana, Ill.....	1867	1868	Selim H. Peabody, PH. D., LL. D.	3	60	11
Purdue University.....	La Fayette, Ind.	1872	1874	Emerson E. White, A. M., LL. D.	2	129	
Iowa State Agricultural College.	Ames, Iowa.....	1869	1869	A. S. Welch, LL. D.....	2	10	5
Kansas State Agricultural College.	Manhattan, Kans..	1863	1863	George T. Fairchild, A. M.	.....	.....	.....
Agricultural and Mechanical College of Kentucky.	Lexington, Ky.....	*c*1865	1866	James K. Patterson, PH D., F. R. H. S., F. S. A.	6	.....	.....
Louisiana State University and Agricultural and Mechanical College.	Baton Rouge, La.	1853	1860	William Preston Johnston.	.....	.....	.....
		1874	1874				
Maine State College of Agriculture and the Mechanic Arts.	Orono, Me.....	1865	1868	M. C. Fernald, A. M., PH. D.	0	0	0
Maryland Agricultural College.	College Station, Md.	1856	1859	William H. Parker.....	.....	6	.....
Massachusetts Agricultural College.	Amherst, Mass.....	1863	1867	Hon. Paul A. Chadbourne, D. D., LL. D.	.....	.....	.....

a Report of normal department is here included.
b Location not fixed, and college not organized at last report, 1880.
c As a department of Kentucky University; new charter in 1880.

STATISTICS OF INSTITUTIONS ENDOWED, &c.—Continued.

Name.	Location.	Date of charter.	Date of organization.	President.	Preparatory department.		
					Instructors.	Students.	
						Male.	Female.
Massachusetts Institute of Technology.	Boston, Mass.....	1861	1865	Francis A. Walker, PH. D.	.....	.....	.....
Michigan State Agricultural College.	Lansing, Mich.....	1855	1857	T. C. Abbott, LL. D.....	0	0	0
University of Minnesota...	Minneapolis, Minn.	1868	1867	William W. Folwell, LL. D.	.....	44	27
Alcorn Agricultural and Mechanical College.	Rodney, Miss	1871	1872	Rev. H. R. Revels, D. D..	5	170	.....
Agricultural and Mechanical College of the State of Mississippi.	Agricultural College, Miss.	1878	1880	Stephen D. Lee.....	3	154	.....
University of the State of Missouri.	Columbia, Mo.....	*a*1839	*a*1840	Samuel S. Laws, A. M., M. D., LL. D.	.....	.....	.....
School of Mines and Metallurgy.	Rolla, Mo	1870	1871	Charles E. Wait, C. E., M. E., director.	2	25	.....
University of Nebraska	Lincoln, Nebr.....	1869	1871	Henry E. Hitchcock, PH. D., acting chancellor.	.....	91	92
University of Nevada *b*.....	Elko, Nev.....	.....	1874	Hon, John S. Mayhugh, (president of board of regents.)	2	22	26
New Hampshire College of Agriculture and the Mechanic Arts.	Hanover, N. H.....	1866	1866	Rev. Samuel C. Bartlett, D. D., LL. D.	.....	.....	.....
Rutgers College.....	New Brunswick, N. J.	.....	1865	Rev. W. H. Campbell, D. D., LL. D.	.....	.....	.....
Cornell University.....	Ithaca, N. Y.....	1865	1868	Andrew Dixon White, LL. D.	.....	.....	.....
University of North Carolina.	Chapel Hill, N. C..	1789	1875	Hon. Kemp P. Battle, LL. D.	.....	.....	.....
Ohio State University.....	Columbus, Ohio...	1870	1873	W. Q. Scott	7	74	19
Corvallis College.....	Corvallis, Oreg....	1868	*c*1865	B. L. Arnold, A. M.....	.....	.....	.....
Pennsylvania State College.	State College, Pa..	1854	1859	George W. Atherton, A. M.	5	66	19
Brown University.....	Providence, R. I....	1764	1765	Rev. E. G. Robinson, D. D., LL. D.	.....	.....	.....
South Carolina College of Agriculture and the Mechanic Arts.	Columbia, S. C.....	1878	1880	William Porcher Miles..	.....	.....	.....
Claflin University and South Carolina Agricultural College and Mechanics' Institute.	Orangeburg, S. C..	1869 1872	1870 1874	Rev. Edward Cook, A. M., D. D.	3	*d*201	*b*115
University of Tennessee and State Agricultural College.	Knoxville, Tenn..	1807 1869	1809 1869	Rev. Thomas W. Humes, S. T. D.	3	92	0
State Agricultural and Mechanical College of Texas.	College Station, Tex.	1871	1876	John Garland James....	0	0	0
University of Vermont and State Agricultural College.	Burlington, Vt...	1791 1865	1800 1865	Rev. Matthew H. Buckham, D. D.	.....	.....	.....
Virginia Agricultural and Mechanical College.	Blacksburg, Va...	1872	1872	Thomas N. Conrad, A. M.	.....	12	0
Hampton Normal and Agricultural Institute.	Hampton, Va.....	1870	1868	Gen. S. C. Armstrong, principal.	4	*e*76	*c*47
West Virginia University....	Morgantown, W. Va.	1867	1867	Hon. W. L. Wilson	.....	102	0
University of Wisconsin....	Madison, Wis.....	1848	1849	Rev. John Bascom, D. D., LL. D.	.....	*f*6	.....

a Missouri Agricultural and Mechanical College, a department of this university, was chartered and organized under the national grant in 1870.
b Preparatory department only organized.
c Organized as an agricultural college in 1872.
d Of these 97 males and 39 females are normal students.
e Besides 48 boys and 26 girls in Indian classes.
f Preparatory Greek class.

Statistics of institutions endowed with the national land grant—Continued.

Name.	Collegiate department.																				Number of scholarships.	Number of years in full course of study.	Number of weeks in scholastic year.	Annual charge to each student for tuition.
	Number of faculty.	Whole number of students.	Students in classical course.								Students in scientific course.								Number of students in partial course.	Number of graduate students.				
			Freshman.		Sophomore.		Junior.		Senior.		Freshman.		Sophomore.		Junior.		Senior.							
			Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.						
Alabama State Agricultural and Mechanical College	11	135	.....	.....	.....	.....	.....	.....	.....	.....	63	.....	34	.....	23	.....	15	.....	.....	.....	.....	4	40	$0
Arkansas Industrial University	11	120	19	3	7	1	12	.....	6	2	2	.....	3	1	.....	.....	.....	.....	64	.....	a1,134	4	40	(b)
University of California	38	246	32	8	23	7	14	5	5	2	21	0	16	1	17	1	14	1	79	.....	.....	4	40	c0
Colorado State Agricultural College	8	56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	4	36	c0
Sheffield Scientific School of Yale College	29	207	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	83	0	56	0	47	0	5	16	30	3	37	100,150
Delaware College	8	54	4	7	4	2	0	0	.....	2	15	.....	7	.....	4	0	7	.....	1	1	30	4	39	60
Florida State Agricultural College *d*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
University of Georgia:																								
Georgia State College of Agriculture and Mechanic Arts	8	39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(e)	4	40	(e)
Southwest Georgia Agricultural College	4	25	.....	.....	.....	.....	.....	.....	.....	.....	18	.....	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	42	f10
North Georgia Agricultural College	6	48	.....	.....	.....	.....	.....	.....	.....	.....	(18)		(13)		(11)		(6)		.....	.....	.....	4	40	f10
Middle Georgia Military and Agricultural College	5	37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	40	f10
South Georgia Agricultural College	5	14	.....	.....	.....	.....	.....	.....	.....	.....	6	.....	8	.....	.....	.....	.....	.....	.....	.....	.....	.....	40	f10
Illinois Industrial University	23	281	.....	.....	.....	.....	.....	.....	.....	.....	63	24	72	19	33	16	31	4	10	9	(0)	4	36	0
Purdue University	12	160	.....	.....	.....	.....	.....	.....	.....	.....	30	17	12	6	13	7	10	1	61	3	g184	4	39	h14
Iowa State Agricultural College	20	211	.....	.....	.....	.....	.....	.....	.....	.....	70	27	42	15	15	12	19	5	3	3	0	4	36	0
Kansas State Agricultural College	i14	ij312	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	37	0
Agricultural and Mechanical College of Kentucky	10	ik320	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(l)	4	38	15
Louisiana State University and Agricultural and Mechanical College.	i8	i159	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0	3,4	39	0
Maine State College of Agriculture and the Mechanic Arts.	9	m90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	4	36	30

a 600 beneficiaries, 400 normal students, 1 honorary appointment from each of the 74 counties, and 60 additional from the State at large.

b Free in all departments of university proper; students in preparatory department without normal or beneficiary appointment pay $30 per annum, and all students pay $5 matriculation fee.

c To residents of State.

d Location not fixed and college not organized at last report, 1880.

e Tuition in July, 1881, was made free; annual fees, $15.

f Incidental fees.

g State appointments.

h Matriculation and incidental fees.

i Total for all departments.

j 224 males and 88 females.

k 249 males and 71 females.

l Each legislative representative district is entitled to send four properly prepared students free of tuition, and each county four normal pupils.

m 87 males and 3 females.

Statistics of institutions endowed with the national land grant—Continued.

Name.	Collegiate department.																							
	Number of faculty.	Whole number of students.	Students in classical course.								Students in scientific course.								Number of students in partial course.	Number of graduate students.	Number of scholarships.	Number of years in full course of study.	Number of weeks in scholastic year.	Annual charge to each student for tuition.
			Freshman.		Sophomore.		Junior.		Senior.		Freshman.		Sophomore.		Junior.		Senior.							
			Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.						
Maryland Agricultural College	7	49	.....	.....	.....	.....	.....	.....	.....	.....	5	.....	7	.....	12	.....	25	.....	.....	.....	(a)	4	40	(a)
Massachusetts Agricultural College	10	113	.....	.....	.....	.....	.....	.....	.....	.....	19	.....	13	.....	13	.....	52	.....	8	8	17	4	39	$36
Massachusetts Institute of Technology	40	*b*390	.....	.....	.....	.....	.....	.....	.....	.....	86	1	31	2	20	0	22	2	*c*226	15	10	4	36	*d*200
Michigan State Agricultural College	20	216	.....	.....	.....	.....	.....	.....	.....	.....	79	2	54	2	31	0	28	1	17	2	.....	4	37	0
University of Minnesota	22	182	11	6	18	8	7	5	10	13	14	2	21	3	5	2	8	2	47	.....	0	4	38	0
Alcorn Agricultural and Mechanical College	3	15	5	.....	5	.....	2	.....	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	39	0
Agricultural and Mechanical College of the State of Mississippi.	9	150	.....	.....	.....	.....	.....	.....	.....	.....	86	.....	40	.....	10	.....	.....	.....	14	.....	.....	4	39	*c*0
University of the State of Missouri	*f*21	*f*435	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(*g*)	*h*6	36	*i*20
School of Mines and Metallurgy	3	57	.....	.....	.....	.....	.....	.....	.....	.....	4	.....	1	.....	7	.....	.....	.....	45	0	0	3	36	*i*20
University of Nebraska	16	101	6	5	4	3	5	1	5	1	7	1	13	3	6	1	2	0	34	4	.....	4	37	0
University of Nevada *j*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	42	0
New Hampshire College of Agriculture and the Mechanic Arts.	*k*7	41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	.....	13	.....	10	.....	.....	0	34	3	37	30
Rutgers College	17	143	16	.....	22	.....	23	.....	26	.....	18	.....	4	.....	8	.....	10	.....	10	6	40	4	36	75
Cornell University	48	384	10	5	18	6	19	5	18	6	83	10	57	7	42	5	30	5	35	23	132	4	36	75
University of North Carolina	13	195	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	47	8	99	4	40	85
Ohio State University	16	124	.....	.....	.....	.....	.....	.....	.....	.....	7	1	11	1	18	1	19	2	62	2	.....	4	37	*l*15
Corvallis College	5	150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60	6	40	30
Pennsylvania State College	12	60	.....	.....	.....	.....	.....	.....	.....	.....	15	3	8	2	8	1	10	0	8	5	50	4	40	0
Brown University	18	264	*m*85	.....	*m*68	.....	*m*59	.....	*m*52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*n*73	4	40	100
South Carolina College of Agriculture and the Mechanic Arts.	4	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	40	0
Claflin University and South Carolina Agricultural College and Mechanics' Institute.	7	23	9	.....	6	2	5	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*o*4	33	0
University of Tennessee and State Agricultural College	11	141	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	275	4	40	80
State Agricultural and Mechanical College of Texas	8	258	.....	.....	.....	.....	.....	.....	.....	.....	213	.....	32	.....	13	.....	.....	.....	0	0	93	4	38	*p*3
University of Vermont and State Agricultural College	10	77	13	3	13	1	10	.....	10	3	8	.....	6	.....	4	.....	3	.....	3	.....	18	4	38	45

Virginia Agricultural and Mechanical College	8	84	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	48	.....	22	.....	10	.....	4	.....	200	4	43	*p*40
Hampton Normal and Agricultural College	*q*18	303	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	95	71	44	30	36	27	.....	.....	215	3	37	0
West Virginia University	12	75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(*r*)	4	41	15–24
University of Wisconsin	31	342	20	19	24	9	19	10	25	9	22	3	17	2	16	1	24	2	119	1	10	4	38	*e*0

a Students from Maryland and the District of Columbia were received free of tuition until 1881–'82; since then all students pay $75 per annum.

b Actual number of students; 15 are twice named in the classification given.

c 39 of these are in the School of Mechanic Arts and 49 in the Lowell School of Practical Design.

d $150 in School of Mechanic Arts.

e To residents of State.

f Exclusive of the Mining School at Rolla and the Schools of Law and Medicine at Columbia.

g $30,000 aid fund.

h Two years only in the Agricultural and Mechanical College.

i Tuition and incidental fees.

j Preparatory department only organized.

k There are also ten occasional lecturers.

l Incidental fees.

m Includes students taking scientific and select courses.

n The income of the $50,000 received from the national grant pays tuition fees of scholars, forty-six in 1880 receiving its aid.

o There are three years in the scientific and agricultural courses.

p To non-residents.

q There are also two teachers in the normal department, seven in the Indian department, eight officers and instructors in the women's industrial department, and eight in the men's industrial department.

r Sixty cadets are educated free of cost for tuition, books, stationery, &c.

Statistics of institutions endowed with the national land grant—Continued.

Name.	Libraries.				Property, income, &c.					
	General library.			Number of volumes in society libraries.	Value of grounds, buildings, and apparatus.	Amount of productive funds.	Income from productive funds.	Receipts for the last year from tuition fees.	Receipts for the last year from State appropriation.	Received from all other sources.
	Number of volumes.	Number of pamphlets.	Increase in last school year in books.							
Alabama State Agricultural and Mechanical College	2,000	.....	.....	1,000	$75,000	$253,500	$20,280	.....	.....	.....
Arkansas Industrial University	1,476	.....	13	.....	170,000	130,000	10,400	$2,000	$5,000	.....
University of California	16,000	4,000	.....	.....	865,000	1,671,204	99,216	200	36,600	.....
Colorado State Agricultural College	150	400	.....	.....	55,000	(*a*)	.....	.....	(*b*)	.....
Sheffield Scientific School of Yale College	5,000	.....	.....	.....	200,000	*c*665,000	12,504	17,798	.....	$16,708
Delaware College	6,000	500	25	3,500	75,000	83,000	4,980	500	0	.....
Florida State Agricultural College *d*	.....	.....	.....	.....	.....	121,400	10,004	.....	.....	.....
University of Georgia:										
Georgia State College of Agriculture and Mechanic Arts	*e*15,000	.....	*e*340	.....	.....	*f*242,202	9,914	.....	.....	.....
Southwest Georgia Agricultural College	.....	.....	.....	.....	.....	.....	2,000	.....	.....	.....
North Georgia Agricultural College	500	.....	.....	.....	20,000	.....	2,000	.....	.....	.....
Middle Georgia Military and Agricultural College	3,000	.....	.....	.....	95,000	.....	2,000	.....	.....	.....
South Georgia Agricultural College	.....	.....	.....	.....	9,000	.....	2,000	1,800	.....	.....
Illinois Industrial University	12,942	2,500	425	0	450,000	319,178	20,660	.....	26,610	29,191
Purdue University	2,065	1,000	262	.....	250,000	340,000	17,161	.....	4,500	5,138
Iowa State Agricultural College	6,000	25	300	0	500,000	600,000	45,000	0	24,000	.....
Kansas State Agricultural College	3,050	520	150	300	125,000	386,165	25,780	.....	.....	3,111
Agricultural and Mechanical College of Kentucky	.....	.....	.....	.....	110,000	165,000	9,900	2,500	16,000	.....
Louisiana State University and Agricultural and Mechanical College.	17,000	2,000	.....	0	400,000	318,313	14,500	0	10,000	0
Maine State College of Agriculture and the Mechanic Arts	4,105	750	131	.....	145,000	132,500	7,500	2,000	3,000	.....
Maryland Agricultural College	.....	.....	.....	1,500	100,000	112,500	6,978	.....	6,000	*g*12,000
Massachusetts Agricultural College	2,300	300	200	.....	205,772	275,000	13,865	4,601	.....	6,379
Massachusetts Institute of Technology	3,000	.....	.....	.....	*h*315,727	267,000	16,672	48,857	.....	.....
Michigan State Agricultural College	6,000	.....	.....	300	338,472	339,058	.....	.....	*i*67,164	.....
University of Minnesota	15,000	1,000	600	0	220,000	575,000	35,000	0	23,000	.....
Alcorn Agricultural and Mechanical College	2,000	500	.....	.....	175,000	113,000	6,000	0	2,000	.....
Agricultural and Mechanical College of the State of Mississippi	830	350	.....	.....	125,000	113,575	5,679	0	*j*120,000	.....
University of the State of Missouri	12,377	13,050	204	.....	150,000	480,000	27,500	11,295	27,000	.....

School of Mines and Metallurgy	1,750	1,000	72	.....	46,660	55,000	3,300	800	7,500	.....
University of Nebraska	4,000	.....	.....	.....	150,000	.....	.....	.....	28,000	.....
University of Nevada *k*	.....	.....	.....	.....	25,000	90,000	.....	.....	6,000	.....
New Hampshire College of Agriculture and the Mechanic Arts	2,000	235	.....	200	100,000	100,000	6,000	.....	*l*3,000	.....
Rutgers College	9,700	3,500	1,300	4,300	400,000	303,129	20,215	3,270	*m*6,960	.....
Cornell University	42,950	12,250	1,300	.....	942,975	1,264,009	105,435	14,750	.....	7,998
University of North Carolina	7,000	3,000	.....	16,000	250,000	142,000	*n*7,500	.....	5,000	*o*6,500
Ohio State University	1,600	500	.....	.....	500,000	559,628	27,866	*p*3,798	6,701	8,272
Corvallis College	200	.....	.....	.....	10,000	60,000	5,000	1,300	.....	.....
Pennsylvania State College	3,000	.....	.....	.....	532,000	500,000	30,000	0	0	.....
Brown University	53,000	17,000	575	0	.....	645,979	36,099	30,896	.....	.....
South Carolina College of Agriculture and the Mechanic Arts	26,500	1,000	.....	.....	25,000	*q*191,800	11,508	.....	.....	.....
Claflin University and South Carolina Agricultural College and Mechanics' Institute.	1,200	.....	.....	.....	10,000	.....	.....	.....	.....	.....
University of Tennessee and State Agricultural College	3,334	300	83	1,015	120,000	409,000	23,960	*r*2,892	.....	311
State Agricultural and Mechanical College of Texas	1,090	300	.....	0	212,000	209,000	14,280	.....	.....	.....
University of Vermont and State Agricultural College	19,400	.....	.....	.....	245,000	248,750	12,231	3,358	.....	6,521
Virginia Agricultural and Mechanical College	700	200	.....	.....	100,000	360,000	20,000	100	.....	.....
Hampton Normal and Agricultural Institute	1,500	640	450	0	420,364	*s*67,208	3,500	.....	*t*10,000	30,000
West Virginia University	5,000	300	250	350	175,000	110,000	6,500	.....	16,500	.....
University of Wisconsin	10,000	1,400	510	0	455,000	498,992	31,749	5,933	44,558	430

a Endowment is the Congressional grant to agricultural colleges, amounting, in Colorado, to 90,000 acres, but not yet sold.

b One-fifth of 1 mill tax, amounting to about $20,000 for the year 1881; there was also a special appropriation of $5,000 for building in that year.

c This includes a large amount of funds received during the past year from the estate of the late Joseph E. Sheffield, no income from which appears in the column of income given.

d Location not fixed and college not organized at last report, 1880.

e University library.

f Entire proceeds of the sale of land scrip, the income of which, $17,914, is, by various acts of the legislature, divided between the State College at Athens and the branches at Cuthbert, Dahlonega, Milledgeville, and Thomasville.

g Average yearly income from students' board bills.

h Fifty-four thousand dollars additional are invested in permanent property.

i For two years; this includes interest on the agricultural fund, which is held by the State as a trust fund for the institution.

j Special appropriation by the legislature of 1882–'83 for the placing of the college on a permanent basis.

k Preparatory department only organized.

l For two years.

m Interest on the $116,000 received from land grant.

n Income from agricultural fund only.

o Includes receipts from tuition.

p From incidental fees.

q This sum is the agricultural fund, and its income is divided between the institution under consideration and that next mentioned.

r Includes all college fees.

s Does not include amount arising from sale of Congressional land grant.

t Income from land grant.

APPENDIX C.

DESCRIPTIONS OF THE WORCESTER COUNTY FREE INSTITUTE OF INDUSTRIAL SCIENCE, WORCESTER, MASS.; THE STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N. J.; AND THE POLYTECHNIC AND MANUAL TRAINING SCHOOLS OF WASHINGTON UNIVERSITY, SAINT LOUIS, MO.

WORCESTER COUNTY FREE INSTITUTE.

[Statement by Principal C. O. Thompson.*]

This institution arose from a conviction on the part of its founders that there is need of a system of training boys for the duties of an active life which is broader and brighter than the popular method of "learning a trade" and more simple and direct than the so-called "liberal education." It is the undoubted opinion of the managers of the institute, and of all who have watched its operation, that the connection of academic culture and the practical application of science is advantageous to both in a school where these objects are started together and carried on with harmony and equal prominence. The academy inspires its intelligence into the work of the shop, and the shop, with eyes open to the improvements of productive industries, prevents the monastic dreams and shortness of vision that sometimes paralyze the profound learning of a college.

GENERAL IDEA.

The institute offers a good education—based on the mathematics, living languages, physical sciences, and drawing—and sufficient practical familiarity with some branch of applied science to secure to its graduates a livelihood. It is specially designed to meet the wants of those who wish to be prepared as mechanics, civil engineers, chemists, or designers for the duties of active life.

ORGANIZATION.

The training of students preparing for mechanical engineers occupies three and a half years; that of all others three years, of forty-two weeks each. There are therefore four classes, viz, apprentice, junior, middle, and senior.

ENDOWMENTS—FUNDS—EXPENSES.

John Boynton, of Templeton, gave	$100, 000
Interest before use on this gift	27, 000
Ichabod Washburn, of Worcester, gave	130, 000
Stephen Salisbury, of Worcester, gave	250, 000
City of Worcester, by citizens	67, 000
State of Massachusetts	50, 000
Total endowment	624, 000
Income from tuition paid by non-resident students a year	1, 500
Value of Boynton Hall and equipment other than chemical and physical apparatus	75, 000
Value of Washburn machine shop and its equipment	55, 000
Value of grounds (seven acres) and one dwelling-house	25, 000
Annual income	24, 000
Annual expense of teaching staff	21, 500

INSTRUCTORS.

Charles O. Thompson, A. M., Ph. D., principal, and professor of chemistry.*
George I. Alden, B. S., professor of theoretical and applied mechanics.
George E. Gladwin, professor of drawing.

*Professer Thompson has resigned and Rev. H. T. Fuller, A. M., has been appointed principal.

John E. Sinclair, A. M., professor of higher mathematics and civil engineering.
Alonzo S. Kimball, A. M., professor of physics.
Edward P. Smith, A. M., professor of modern languages.
Thomas E. N. Eaton, A. M., junior professor of mathematics.
Milton P. Higgins, B. S., superintendent of machine shop.
Walter U. Barnes, B. S., assistant in chemistry.
Aldus M. Chapin, C. E., instructor in field work.
Paul A. Chadbourne, D. D., LL. D., lecturer in geology.
Number of students, all boys, 93; average age at entrance, eighteen and three-quarters years.

The institution is open to all qualified applicants regardless of locality, and students are in attendance now from Pennsylvania, Maine, Connecticut, New Hampshire, Rhode Island, Ohio, Texas, California, Minnesota, the District of Columbia, and Chili. But all residents of the county of Worcester and 23 residents of Massachusetts and not of Worcester County are entitled to free tuition. Others pay $150 per annum.

SCHOLARSHIPS.

Resolve of Massachusetts Legislature, approved May 10, 1869.

Resolved, That there be allowed and paid out of the treasury of the Commonwealth the sum of $50,000 to the Worcester County Free Institute of Industrial Science. And in consideration of this grant, said institution shall annually receive twenty pupils, and instruct them during the entire course, free of tuition; such pupils to be selected by the board of education from the different counties in this Commonwealth, except that none shall be taken from Worcester County.

Three students from that part of Norfolk County, viz: from the towns of Bellingham, Foxboro', Franklin, Medway, Walpole and Wrentham, which formerly made part of the ninth Congressional district, may receive free tuition in accordance with the terms of the gift of Hon. George F. Hoar.

Applications for these scholarships are filed at the institute as soon as received. After the entrance examination, successful candidates receive the scholarships in the order of application.

GRADUATES.

Summary of employments of graduates, liable to daily change.

Whole number of mechanical engineers	88
All others	98
	186

Of the mechanical engineers, 26 are journeymen; 21 are superintendents, foremen, or proprietors of manufacturing establishments; 10 are draughtsman; 5 are mechanical or civil engineers; 3 are farmers; 1 is a chemist; 3 are teachers; 18 are engaged in miscellaneous business, generally in manufactures; 1 is dead; total, 88.

Of the graduates from other departments, 36 are civil engineers; 3 are superintendents or foremen; 11 are teachers; 7 are draughtsmen or designers; 3 are journeymen mechanics; 6 are chemists, assayers, or apothecaries; 1 is a farmer; 27 are engaged in miscellaneous occupations in active business; 4 are dead; total, 98.

Inasmuch as a large number of those reported as engaged in miscellaneous business are really in positions in factories and mills with a certain prospect of promotion, and where their technical training is indispensable, it is correct to say that 90 per cent. of the graduates of the institute are occupying positions for which their training directly prepared them.

Note.—All graduates are urged to begin life at the bottom and depend upon their education for *speedy advancement*.

OUTLINE OF THE COURSE OF STUDY.

Recitations and practice are assigned to the classes according to the following scheme, the figures indicating hours per week:

FIRST HALF-YEAR.

Seniors.—Theoretical mechanics, 5; French or German, 3; English, 2; chemistry, 2; physics, 4; mechanical drawing, 6; practice, 10. *Middlers.*—General geometry, 5; de-

scriptive geometry, 3; German, 2; English, 1; chemistry, 4; free drawing, 2; mechanical drawing, 6; practice, 10. *Juniors.*—Algebra, 4; geometry, 4; German, 2; English, 1; chemistry, 2; free drawing, 6.

SECOND HALF-YEAR.

Seniors.—Applied mechanics, 5; French or German, 3; English, 2; chemistry, 4; mechanical drawing, 6; practice, 10. *Middlers.*—Calculus, 5; German, 3; English, 1; physics, 4; free drawing, 2; mechanical drawing, 6; physics, 4; practice, 10. *Juniors.*—Trigonometry, 4; algebra, 4; German, 3; English, 1; chemistry, 4; free drawing, 6; practice, 10. *Apprentices.*—English, 5; free drawing, 10; shop practice, 39.

INSTRUCTION TO WOMEN.

Several women have enjoyed the full advantage of the institute, receiving instruction in return for service as assistants in the office.

The third supplement of Watts's Dictionary of Chemistry, London, 1879, page 426, sets out the work of Miss Mary F. Reed as an original contribution to knowledge.

This work was done in this laboratory, and is the only original woman's work in chemistry, so far as I know, which has secured notice in Watts's Dictionary.

BUILDINGS, WORK-ROOMS, SHOPS, LABORATORIES, ETC.

Rooms and utensils.—Boynton Hall is a commodious granite building, 146 feet long by 61 feet wide, built by the citizens of Worcester. It contains a chapel capable of seating four hundred persons; a lecture room, in the rear of which are a store room and private laboratory, with store and balance rooms; furnished with all the tables, reagents, &c., necessary for the students' use; a laboratory, fully equipped for instruction in chemistry; a physical laboratory, furnished with power from the shop and adapted to the use of students in the practical solution of problems in physics, containing Willis's apparatus, complete working machines to illustrate the movements of the link and valve; C. H. Morgan's machine for showing the correct forms of cams and their movements; models of bridges, thermic, optical, and galvanic apparatus to meet every want; two commodious drawing rooms, one for freehand, the other for mechanical drawing, with model rooms, where are the best French and English plates, manuscript drawings, models, casts, &c., a designer's room, commodious recitation rooms, and office room. There is also a full set of instruments for the use of the civil engineers. Through the generosity of a constant friend the institute has come into possession of the celebrated Chevallier universal microscope, which was imported by the late Francis Peabody, esq., of Salem.

The Fairbanks testing machine, which was on exhibition at the Centennial and received an award, has been added to the apparatus of the physical laboratory for the purpose of instruction. This machine has a capacity of 52,000 pounds, and is of universal applicability to the determination of the strength of materials.

Books.—There is a small library of books of reference at the institute. Through the liberality of the trustees of the Green library, which contains 45,000 volumes, students share in its use with the citizens of Worcester. All new standard works in technical literature are promptly added to this library as they appear.

The library of the American Antiquarian Society, of 60,000 volumes, is accessible to students.

Practice.—The Washburn machine shop offers unusual facilities to students in this department for obtaining a practical knowledge of the use of tools and the management of machines. The shop is equipped with the best tools and machinery for the working of iron and wood, and is managed by a superintendent, who employs a sufficient number of skilled workmen. The students spend their practice hours in it as apprentices. Besides the general training in drawing, the mechanical engineers have special instruction during senior year in making working drawings of machines, determining the strength, dimensions, and proper proportions of machines from numerical specifications and in the laws of motors. It is the main purpose of the shop to carry out the wise and comprehensive plan of its founder, the late Hon. Ichabod Washburn, of Worcester, as expressed in the following extract from his letter of gift, dated March 6, 1866:

"There shall be a machine shop of sufficient capacity to employ 20 or more apprentices, with a suitable number of practical teachers and workmen in the shop to instruct such apprentices, and provided with all necessary steam power, engines, tools, apparatus and machinery of the most improved models and styles in use, to carry on the business of such machine shop in all its parts as a practical working establishment. There shall be a superintendent of such shop, who shall be appointed and subject to be removed by the trustees, who shall be a man of good morals and Christian character, having a good English education, a skilfull and experienced mechanic, well informed and capable of teaching others in the various parts and processes of practical mechanism usually applied

or made use of in the machine shops of the country, who shall devote his time and attention to the management and business of the shop, purchasing stock, making contracts for the manufacture and sale of machines, and other work usually done in machine shops, subject to such rules as the trustees may prescribe, and having charge of the proper financial concerns of the shop, hiring necessary workmen, and discharging the same at his discretion, and shall see that the apprentices are suitably taught in all the departments of practical mechanism, working of wood and metals, and use of tools, so as to make them, so far as may be, skilled workmen, and fitted to carry on business for themselves after they leave the shop at the expiration of their apprenticeship.

"He shall, moreover, have a care and oversight over the apprentices, such as a faithful master would exercise, to the end that they may cultivate habits of industry, good conduct, and attention to their studies."

The shop is a three-story brick building, 100 feet long by 40 feet wide, with a wing 65 by 40 feet, for engine, boilers, and blacksmith shop. These rooms are all equipped according to the directions of the benevolent donor.

Students who desire instruction in mechanics according to the present arrangement must enter the apprentice class, unless they have already attained adequate proficiency in the use of tools and machinery.

As much variety as possible is sought in the kind of work assigned to students. In general the apprentice class learn something of the use of wood-working tools and machinery; the junior, middle, and senior classes work mainly on iron.

Practice in the machine shop and drawing room is given in manufacturing the products enumerated in the catalogue. It comprises—

IN THE WOOD ROOM.

Benchwork.—This includes a great variety of manipulation, under constant instruction, in laying out work with knife and pencil, the use of the planes, the handsaws, chisels, gouges, squares, gauges, and other tools.

Wood turning—with the use of the various turning tools, on hard and soft woods.

Machine sawing—with large and small circular saws, and scroll-saws.

Machine planing—with the cylinder and Daniels planer.

Machine boring, the use of the shaping and moulding machines and the auxiliary manipulations of all the machinery used.

IN THE IRON ROOM.

Benchwork.—Filing and chipping, preparing work for lathes, tapping, reaming, scraping, and fitting plane surfaces, finishing with oilstone and emery cloth.

Work with speed lathe.—Drilling and countersinking, filing and polishing, hand-tooling.

Work with engine lathe.—Instruction in the use and care of lathe and turning tools, squaring up, the proper and maximum speed for cutting metals, turning to exact size, the use of the calipers, a variety of turning, both heavy and light, cutting threads, squaring up and finishing nuts, chucking straight holes, reaming, inside boring, boring with boring bar, fitting bearings, &c.

Drilling—with speed-lathe, upright and traverse drillers.

Milling—Use of universal milling machine, milling nuts, bolt heads and studs, cutting splines, fluting taps and reamers, milling to size and line, cutting gears.

Planing—Instruction in the use of the planer, planing surfaces and bevels.

Work with screw machine—Making machine bolts with revolving head screw machine, cutting up stock, making screws and studs and tapping nuts.

Tool making —The correct forms of turning-tools and the principles of grinding them, making taps, dies, reamers, twist drills, countersinks, counterbores, mills, milling machine cutters, mandrels, boring bars, chuck drills, centres.

Management of steam—Care of the boilers and engine, including the work of firing, the care and the control of the steam pressure, the water supply; also the care and manipulation of the steam pump and injectors. This practice in the steam department is under the constant oversight of the engineer.

Designing and constructing.—At some point in senior year, after the students have each accomplished the practice just specified, they will receive instruction in designing machinery and undertake the building of one or more complete machines from their own drawings. These drawings, though made from definite specifications, are intended to afford ample field and scope for the personal responsibility and originality of each student in making correct design and arrangement of the parts of the machine in hand. While this work is not copying, it must not depart essentially from the best practice among manufacturing mechanics. The present senior class are constructing a Corliss engine.

CIVIL ENGINEERING.

The civil engineers join the mechanical engineers in the study of theoretical mechanics.

In applied mechanics they solve problems relating to the stresses and strains in girders, roofs, and trusses, the suspension bridge, the stability of the arch, the strength of boilers, pipes, and thick hollow cylinders, deflection and designing of beams, the stability of dams, reservoir walls and retaining walls, the pressure of earth and stability of earth foundations, the energy of liquids in motion, the construction of water-wheels, and other problems relating to engineering structures.

PRACTICE.

A full equipment of transits, levels, chains, &c., is provided for the instruction of the students in practice in the different branches of civil engineering.

The junior class study Gillespie, solve problems in the field, in mensuration, triangulation, leveling and general topography. All field notes are carefully plotted and reported.

The middle class, after studying Henck's Field Book and Davis's Earth Work, proceed with a practical application of the information thus obtained to locating highways and laying out lines of railroads, setting slope stakes, and making calculations for excavations and embankments.

The senior class study Mahan's Stereotomy with practical problems, Gilmore's Limes, Hydraulic Cements and Mortars, and Gilmore's Roads, Streets, and Pavements.

CHEMISTRY.

The general course in chemistry is calculated to give every student a clear understanding of the general principles of the science, and is taught to all students by means of laboratory manipulation and class-room drill.

This course begins with twenty lectures, followed by ten two-hour lessons in laboratory manipulation in the first half of junior year. During the second half the class have sixty recitations in Barker's Chemistry.

In the first half of middle year, forty two-hour lessons are given in wet analysis.

In the first half of the senior year twenty lessons in organic chemistry are given; in the last half, a course is given in the use of the blowpipe and determinative mineralogy, followed by lectures on metallurgy.

PRACTICE.

Practice in the chemical laboratory, for those who intend to be practical chemists, includes, in addition to the general course, the following subjects:

Junior class.—Blowpipe analysis, beginning with dictation lessons in the use of the blowpipe with its auxiliaries, and concluding with the determination of fifty minerals according to Dana's classification.

Qualitative analysis, dictation lessons, and examination of fifty mixtures.

Middle class.—Use of the balance, and gravimetric problems with use of Fresenius' quantitative analysis.

Volumetric analysis with use of Sutton's text-book.

Senior class.—Blowpipe assaying of gold, silver, mercury, lead and copper; furnace assaying of gold, silver, lead and iron. Analysis of iron, steel and slags, milk, beer, water and fertilizers.

PHYSICS.

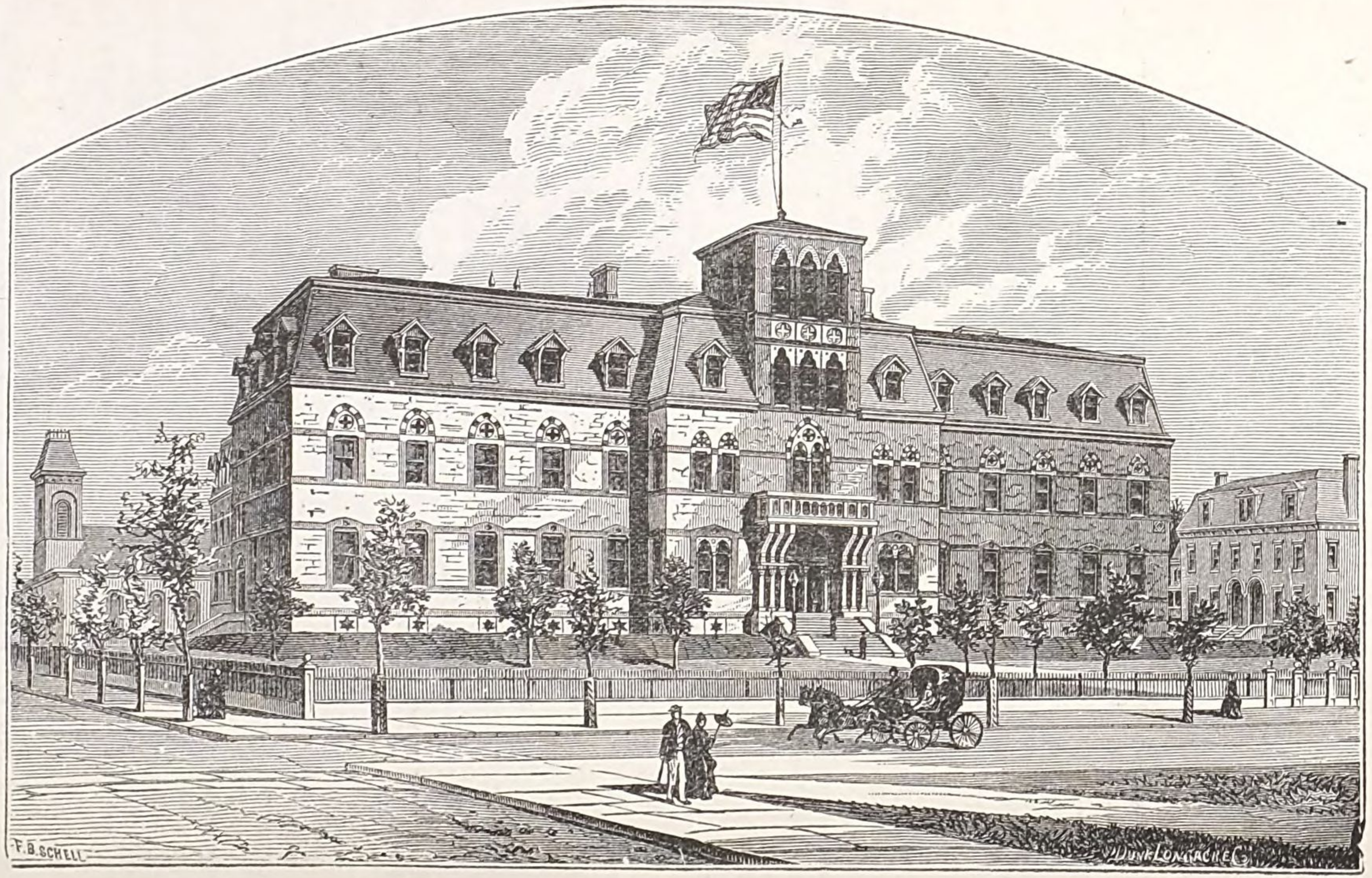
All students receive instruction in the subject of general physics, which is amply illustrated. Students who are qualified by previous mechanical training, or by special aptness or taste for physical research, may practice in the physical laboratory.

The entire course in this department offers to the student facilities for the acquisition of an exact knowledge of the elementary principles of physics.

PRACTICE.

Students in this department, in addition to the general course, spend their practice hours in the physical laboratory.

The laboratory possesses a collection of apparatus specially constructed for the practical solution of physical problems, among which are the Fairbanks testing machine, dynamometers, apparatus for determining the tension of steam, latent and total heat of vaporization, a model boiler and fittings for determining the efficiency and economy in use of boilers, &c.



STEVENS INSTITUTE OF TECHNOLOGY.

[S. Ex. 25——face p. 261.]

The students perform experiments involving measurements in each branch of the science treated in the lectures of the general course. The strength of materials, the fall of bodies, the pressure and flow of liquids and gases, the vibration of sounding bodies, focal distances of lenses, indices of refraction, latent and specific heat, tension of vapors, resistance of telegraphic wires and cables, electro-motive force of batteries, and strength of currents are among the problems assigned for laboratory practice.

Experimental investigations are carried on by the students under the direction of their instructor, and experience has shown that as a means of discipline special researches of this kind are more valuable than systematic work following a text-book.

DRAWING.

All students are taught freehand drawing. By carefully studied exercises in outline drawing, shading and coloring, from copies, models and casts, and by blackboard work, discipline of the sense of form and proportion is secured, and an ability to delineate objects is acquired which is of great value in all departments of applied science.

In the mechanical drawing-room instruction is given in the use of instruments, shading and coloring, plane and isometric projections, and the theory of shades, shadows and perspective. All drawing is done under the eye of the instructor.

PRACTICE.

Students who evince marked power in drawing are admitted to practice in this department.

A course of lessons is devised for each student in practice, preparatory to designing for textile fabrics, lithography, &c. Students enjoy access to collections of illustrations and examples. Students who practice in drawing join the civil engineers in the study of stereotomy.

The course in drawing is the best preparation for the business of a designer, whether for prints, fresco, and ornamental painting, or any other similar art.

Every student in the department of mechanics, in addition to the work just specified, is required to make at least one complete set of working drawings in the shop under the direction of the superintendent, for use in the shop.

Stevens Institute of Technology.

The Stevens Institute of Technology, Hoboken, N. J., is a school of mechanical engineering. It owes its foundation to the bequest by the late Edwin A. Stevens of a valuable lot of ground in Hoboken and several hundred thousand dollars (about $650,000) for the establishment of "an institution of learning for the benefit, tuition, and advancement in learning of the youth residing from time to time, in future, within the State of New Jersey." The executors of the will determined what should be the nature of the instruction given. The endowment of the institute is about the same as at the time of its opening in 1871. Its grounds, buildings and apparatus are valued at $400,000; its productive funds amount to $410,000; the income from them for the year 1880 was $30,000, and the income from tuition fees was $13,840.

The faculty consists of a president, and professors of physics, mechanical engineering, mathematics and mechanics, mechanical drawing, chemistry, languages, belles-lettres, and experimental mechanics and shop work. Its members have supplemented the work of teaching by making original investigations and contributing largely to scientific and technical literature. The students in attendance in 1880 numbered 144, of whom 20 were seniors, 25 juniors, 46 sophomores, and 53 freshmen.

The expenses of the student for tuition are $150 per annum if he reside at the time in New Jersey; $225 if he come from any place outside the State, New York City, for example. In the chemical laboratory he must pay for injuries to apparatus, and in the department of shop work for the material used, the cost of which is estimated at $65 for the entire course. The tuition of a limited number of students is covered by scholarships, as follows: One scholarship each year is given to the graduate of the high school connected with the institute who passes the best examination at the end of the spring term. Three scholarships each year are given to recommended graduates from the public schools of Hoboken.

Previously to 1881, 83 young men had graduated. Nearly all of them took the degree of mechanical engineer, and immediately engaged in professional work in desirable places. The president of the trustees of the institute recently said: "Our graduates have borne splendid testimony to the men who have trained their minds and their hands to work.

Wherever they have gone they have made their mark. There is an air of seriousness about them in their course of study that shows even to the casual observer that they are here for work; and when they go out from us they show that they have been trained to work with head and hands."

COURSE OF STUDY.

The full course of study covers four years, each year being divided into a preliminary term of one month (during which the sophomore, junior, and senior classes devote eight hours a day to experimental mechanics and shop work) and three regular terms of combined lecture, recitation, and shop work. The following plan of instruction is given in the catalogue:

The plan of instruction which has now been successfully pursued for ten years is such as will best fit young men of ability for positions of usefulness in the department of mechanical engineering and in those scientific pursuits from which this and all the sister arts are daily deriving such incalculable benefits. With this view there is afforded:

(1.) A thorough training in the elementary and advanced branches of mathematics and their application to mechanical constructions.

(2.) The subject of mechanical engineering, including theory and practice in the construction of machines, forms a distinct department, under the charge of professors experienced in the practical relations of this subject, who devote their entire attention to this branch.

A mechanical laboratory has been instituted as an adjunct to this department, in which students are permitted to study the materials of construction during the process of testing, which is at nearly all times in progress, and frequently to take part in such work. They are given opportunities to take part in tests of steam engines, boilers, and other operations carried on in this laboratory, and engage in the construction of machinery and other work done in the workshop. Much of this work is made from designs produced by students, and some machines here used are the work of students entirely.

(3.) The subject of mechanical drawing (which may well be called the language of engineering) forms a separate department, to which much time and attention is devoted.

The course comprises the use of instruments and colors, descriptive geometry, shades, shadows, and perspective, and the analysis of mechanical movements, the principles involved being at once and continuously applied in the construction of working drawings from measurements of machines already built, as well as in making original designs.

(4.) Arrangements of an unusually perfect character have been made, to give a thorough, practical course of instruction in physics, by means of physical laboratories, in which the student is guided by the professor of physics, in experimental researches bearing upon the subjects of his special study.

Thus the student will experimentally study those methods of making measures of precision which are used in all determinations in physics; he will measure for himself the tension of steam at various temperatures, and construct the curve showing their relations; he will determine the electrical resistance of several conductors and insulators, and so on through the subjects of physics.

By such means as these not only will facts and laws be impressed in a manner which no other process can approach, but a training will be given in methods of investigation which will be invaluable for the mastery of the always new and varied problems of actual work.

(5.) The subject of chemistry is taught chiefly by experimental work in the laboratory, with accompanying lectures and class room instruction. It is believed that in this manner only can students be made thoroughly conversant with the subject.

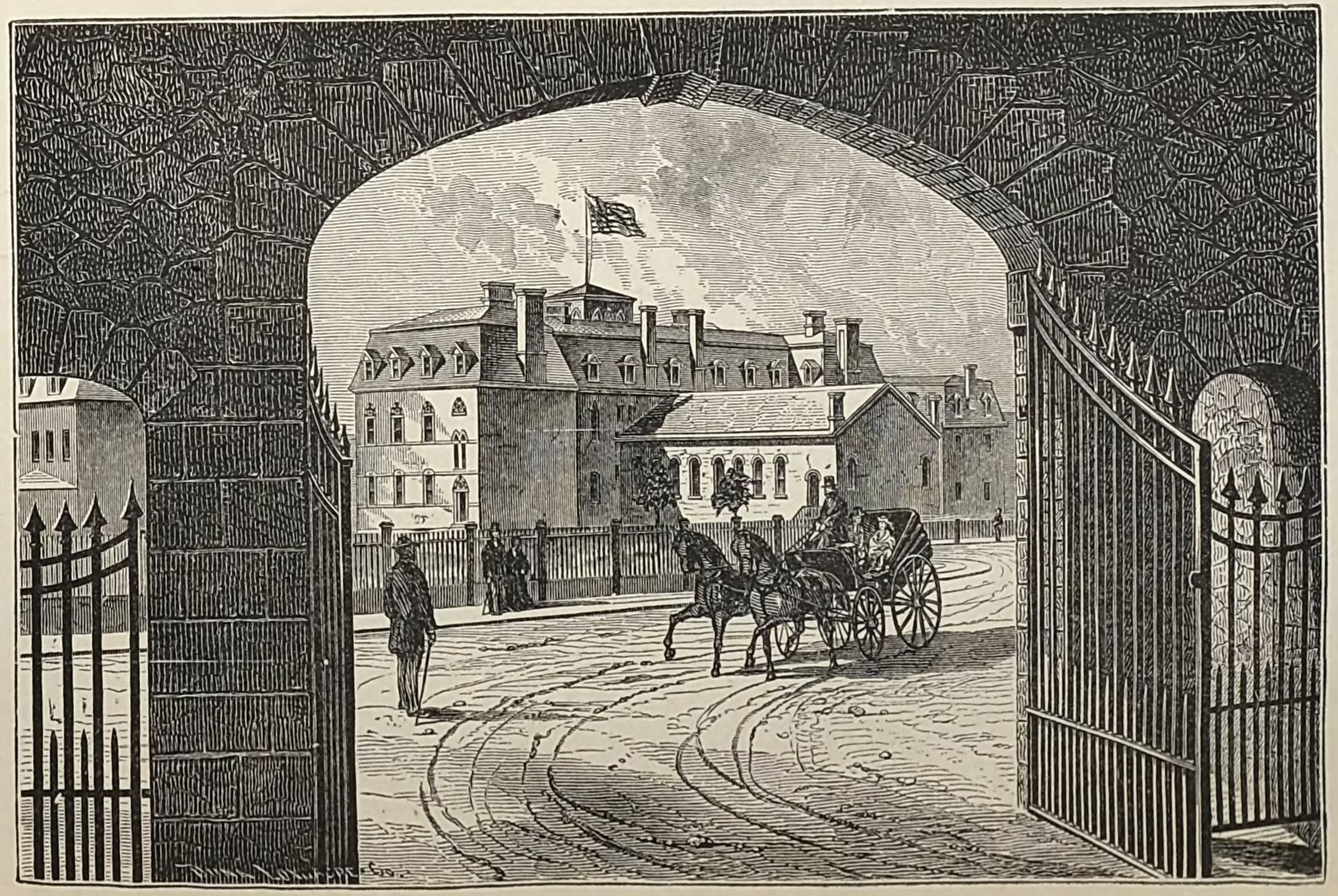
(6.) The French and German languages form an essential part of the course of instruction, since they are indispensable to the engineer and man of science as the vehicles of a vast amount of information, and also as affording that kind of mental culture which mathematical and physical science, if followed exclusively, would fail to supply.

(7.) A department of belles-lettres furnishes the means of cultivating literary taste and a facility in the graceful use of language, both in speaking and writing, which are as desirable in the engineer and man of science as in the classical student.

INDUSTRIAL DEPARTMENTS.

The departments of physics, mechanical drawing, and mechanical engineering have a direct bearing upon the industrial work of the institute, and therefore are worthy of special description.

The department of physics is organized for purposes of instruction and original research. The instruction of the first year is upon the inductive method of research, the general properties of matter, inductive mechanics, pneumatics, the laws of vibratory motion, acoustics, and light. The second year is devoted to the study of heat, light, mag-



REAR VIEW.

[S. Ex. 25——face p. 262.]



PHYSICAL LABORATORY

[S. Ex. 25—face p. 263.]

netism, and electricity. During the third year the professor of physics lectures upon the modes of making exact measures, shows the application of these measures in the various departments of science, and explains the construction, the methods of adjustment, and the manner of using instruments of precision. The fourth year is spent in the physical laboratories upon experimental investigations, schedules of which are prepared by the professor.

The physical laboratory is provided with a complete outfit of all instruments of research and exact measurement, including numerous forms of dividing engines, cathetometers and comparators, spectroscopes, microscopes, electrometers, galvanometers, electric resistance coils, &c. Among recent additions is the original circular dividing engine of James Ramsden.

The department of mechanical drawing was so organized as to make the course of instruction thorough, practical, directly useful, and comprehensive. The foundation of future acquirement is secured by practice in the simple drawing of lines. Elementary studies of projection are afterward taken, the method adopted being that of beginning by making the drawings of a solid object bounded by plane surfaces in varied positions and proceeding to more complex forms. The next step is the drawing of parts of machines from actual measurements and the study of descriptive geometry. Shades, shadows, and perspective are not of primary importance to the mechanical engineer, and therefore are not long studied. More attention is paid to practical exercises in the plotting of mechanical movements, the drawing of the various forms of gearing, and the construction of curves representing varied motion and the like. The course also includes some actual planning. A subject is assigned or selected. The student proceeds to actual work upon it, makes a skeleton diagram of the movement, sketches in the proposed arrangement of parts, calculates their strength and proportion, modifies the original plan accordingly, draws each part in detail and finally makes a general plan of the completed design.

The department of mechanical engineering provides thorough instruction in those subjects which belong exclusively or preëminently to that field of study, and supplies such practice as gives a knowledge of appliances, processes, and methods necessary to the construction of such mechanical designs as the student may be taught to originate. The workshop course consists of (1) carpenter work and wood turning, mill wrighting and steam fitting, which are pursued by the freshman class; and (2) machinist work, blacksmithing, moulding and founding, and pattern making, which are pursued by the sophomore and junior classes. In the carpenter shop the student is first taught the preparation of tools for work and afterward given some twenty exercises in planing, sawing, framing, &c. The instruction in wood turning is upon the care and management of the lathe, the production of prescribed forms and figures, and the behavior of different woods while being operated upon. The practice in millwrighting and steam fitting is likewise thorough and complete.

The machinist work includes eleven exercises in vise work; ten in planing, besides six preliminary exercises in the management of the machine; familiarization with the movements and management of milling machines, ten exercises in their regular use, and eight in gear-cutting; sixteen exercises in drill press work; miscellaneous drilling by hand; and some forty exercises with the metal lathe. The course is finished by the student being sent to examine the kind, size and use of tools and machines employed in various manufactories and mills, and the methods adopted in the production of heavy machinery. The courses in blacksmithing, moulding, and founding, and pattern making are arranged with similar care. The institute has been provided for a considerable time with a machine and carpenter shop, an iron and brass foundry, and a blacksmith shop. It has increased their equipment from time to time.

In 1881 a new machine shop was fitted up and presented to the institute by President Morton. A description of this is given as follows:

"The building occupied by this shop is 50 feet by 80 feet on the floor, with a high open roof, and galleries running around all four sides.

"A Buckeye engine, placed near the center, drives two lines of shafting which run along the fronts of the galleries, and from these belts pass off to the countershafts of the various machine tools.

"A spiral stairway gives access to one of the galleries near its center, where is placed the tool room, in which are systematically arranged all the small tools, such as drills, cutters, taps and dies, mandrils, gauges, &c., which are used with the machine tools.

"The machine tools on the main floor consist of fourteen lathes of different sizes, from one of 22 inches swing and 12 feet bed downward, all by different makers, and thus presenting a wide range of variation in style and structure; two planers, with beds 20 inches by 5 feet; two drill presses; and one universal milling machine. There are, besides, grindstones and emery wheels, driven by power, and a large number of vises, work benches, sets of wood working tools, and all other accessories."

A mechanical laboratory was established in 1875, in which have been tested steam boilers and engines, the value of lubricants, the strength of building materials, the physical and mechanical properties of iron and steel, and many other structures and substances. The other laboratories are also thoroughly furnished, and collections illustrative of the sciences are not wanting.

WASHINGTON UNIVERSITY.

[Statement from latest reports and catalogues.]

Washington University, Saint Louis, Mo., was founded in 1853. It is intended to embrace the whole range of university studies, except theology, and to afford opportunity of complete preparation for every sphere of practical and scientific life. Seven departments have been established, viz: Smith Academy, in which primary, secondary, and preparatory instruction is given; Mary Institute, a female seminary located apart from the central university; the college proper; a school of fine arts; a law school; a manual training school; and the O'Fallon Polytechnic Institute. In this polytechnic school there are courses in civil engineering, mechanical engineering, chemistry, mining and metallurgy, and building and architecture. They extend through four years, and are intended to prepare for professional work in the departments of engineering, chemistry, and architecture. The studies are the same for all the courses during the freshman and sophomore years. They include higher mathematics, surveying, drawing, descriptive geometry, physics, chemistry, history, modern languages, English studies, and shop work. The courses are so arranged for junior and senior years as to include only studies directly contributing to training in the professions to which they are preliminary. The course in chemistry has only geology, mineralogy, and political economy, in addition to distinctly chemical work. The course in mining and metallurgy consists principally of technical studies, such as the occurrence of minerals, the opening and ventilation of mines, accidents, the transportation and preparation of ores, furnaces, fuels, metallic compositions, and processes employed in manufacturing.

The courses in civil engineering, mechanical engineering, and building and architecture include many subjects common to all. These are, in junior year, differential calculus, descriptive geometry, drawing, chemistry, English composition, and shop work; in senior year, mechanics, drawing, political economy, and shop work. The civil engineering course is accompanied by laboratory and field practice, and includes practical astronomy. The course in mechanical engineering gives special prominence to shop work; that in building and architecture, to designing, modeling, architectural drawing, and engineering.

DEPARTMENT OF ENGINEERING—APPLIANCES AND METHODS OF STUDY.

The institute has a choice and extensive collection of photographs, models, and other appliances illustrating the principles of civil and mechanical engineering. Its laboratory of mechanical engineering is large, and equipped for testing boilers, engines, and machinery in general. The shops of the manual training school are open to the students, and the use of tools for working word and iron is systematically taught.

The instruction in all branches of study is given from text books when practicable, and supplemented by lectures and practical work.

Every effort is made to give the best engineering practice, both European and American, and to keep pace with the great advances made on all sides in every department of physical science. Special prominence is given to the use of graphical methods which are most advantageously employed in supplementing the processes of computation. Advantage is taken of the opportunities afforded by the city and the vicinity for the study of manufactories, machinery, and engineering works.

DEPARTMENT OF MINING AND METALLURGY.

This branch of the institute was organized in 1871. The instruction is given by means of lectures and recitations on various subjects pertaining to the course; practical work in the physical, chemical, and metallurgical laboratories; field work in geology; projects, estimates, and plans for the establishment of mines and metallurgical works; and the examination of mines and manufacturing establishments. The collections of the department are increasing rapidly, and now include a series of models of crystals and specimens illustrating the various minerals and rocks and their associations, ores, coals, petroleums,

fire clays, and building materials; botanical and zoölogical forms; characteristic fossils of the different zoölogical ages; metallurgical products, &c. Special facilities are offered for critical studies in microscopic lithology.

The following is a statement of the number of specimens in collections in September, 1882:

Crystal models	250
Minerals	15,000
Rocks	5,000
Microscopic preparations (rocks and minerals)	1,000
Fossils	40,000
Casts of large animals	250
Corals and shells (modern)	2,500
Zoölogical	300
Botanical	1,000
Archæological	1,500
Metallurgical	3,000
Total	69,800

The assay laboratories are completely furnished with crucible, scorification, and cupelling furnaces, and everything necessary for practical work in the assay of the principal ores. From a large stock of these obtained from various parts of the country the students are required to make a large number of assays.

In the numerous finely equipped chemical laboratories a practical course is pursued in connection with lectures on qualitative and quantitative analysis. The students are required to make tests and full analyses of coals, limestones, ores, clays, technical products, &c. An assistant is in constant attendance in the assay and metallurgical laboratories, to aid in the practical work assigned.

During the summer vacation the students are required to visit some mining or metallurgical district, and at the opening of the following term they hand in a journal of travels, with a report of the operations conducted in the region visited, illustrated with drawings. Before receiving their degree (engineer of mines) they execute plans for the establishment and working of mines or smelting-works under given conditions, with drawings, estimates, and written memoirs.

PHYSICAL LABORATORY.

The physical laboratory is provided with large tables fitted up for the purpose of enabling the students to perform certain assigned experiments in mechanics, pneumatics, heat, optics, acoustics and electricity. These experiments are increasingly elaborate as the student advances, and their purpose is to give an insight into the methods and means used in physical investigation.

DRAWING DEPARTMENT.

With the beginning of the freshman year freehand drawing from the "round" or solid is practiced, first in outline, then in shading with charcoal. In the first stages of freehand shading there is but little attempt made at finishing work; the student is urged to gain the power of expressing rapidly a clear idea of the object before him by means of his drawing rather than to attempt an artistic production.

Instruction in the conventional use of color and the use of the brush in shading as applied to mechanical and architectural drawing is taken up at this stage of the work.

Regular students of the sophomore class use as models during the time allotted to freehand work parts of machinery, casts of ornaments, &c. During the first term they spend some time in sketching from nature. The time devoted to mechanical drawing is spent in line and brush shading, lettering, &c.

During the second term the time is devoted to machinery, architectural, and map drawing. Recently a course in sepia painting has been partly introduced in the work of this class.

The junior class in civil engineering work from models, arches, &c., finishing with pen and ink, India ink with brush, and also practice sepia and water color painting.

The senior class in civil engineering devote the time allotted to drawing in finishing drawings from actual measurement and the designing of structures. The drawings are executed with pen and ink, brush-shading in sepia or India ink and water color.

The course pursued by the classes in mining engineering differs only in the objects used as models. The juniors execute drawings of profiles, crystals, plans, and sections of mines and mining machinery, furnaces, apparatus, and machinery of smelting works. Seniors execute similar work from actual measurement and constructions.

MANUAL TRAINING.

In the enumeration of studies the word "shopwork" is used to cover the systematic course of instruction and practice in the use of the more common hand and machine tools. As at present arranged "shopwork" is required of all engineering students, and is available to all others. Generally four hours per week are given to the shop, the practice lasting a year in each one of the four shops: carpenter shop, turning shop, blacksmith shop, and machine shop. It is believed that the value of the training which students can obtain in from four to twelve hours a week of shop work is abundantly sufficient to justify the expense of materials, tools, and expert teachers, whatever may be their plans for the future. No branch of study has been omitted from the theoretical work on account of the shop practice. The standard of scholarship has not been lowered. The knowledge of practical matters and the ability to use tools do not displace but supplement abstract and theoretical work.

MANUAL TRAINING SCHOOL OF WASHINGTON UNIVERSITY, ST. LOUIS, MO.

The manual training school of Washington University was established as a separate and independent department of the university in June, 1879, and opened in September, 1880. It owes its existence to the conviction on the part of its founders that the interests of Saint Louis demand for young men a system of education which shall fit them for the actual duties of life in a more direct and positive manner than is done in the ordinary American school. Its plan is outlined in Article II of the ordinance establishing it, which is as follows:

OBJECT.

"Its object shall be instruction in mathematics, drawing, and the English branches of a high school course, and instruction and practice in the use of tools. The tool instruction, as at present contemplated, shall include carpentry, wood-turning, pattern-making, iron chipping and filing, forge work, brazing and soldering, the use of machine shop tools, and such other instruction of a similar character as it may be deemed advisable to add to the foregoing from time to time. The students will divide their working hours as nearly as possible equally between mental and manual exercises. They shall be admitted on examination at not less than fourteen years of age, and the course shall continue three years."

STUDIES.

Applicants for admission must pass a good examination in the leading rules of arithmetic, common school geography, spelling, and penmanship, and the writing of good English.

The arrangement of studies and shop work by years is substantially as follows:

First year: Arithmetic completed, algebra to equations, the structure and use of the English language (or Latin), history of the United States, physical geography, mechanical and freehand drawing, penmanship, carpentry and joinery, wood carving, wood turning, and pattern making.

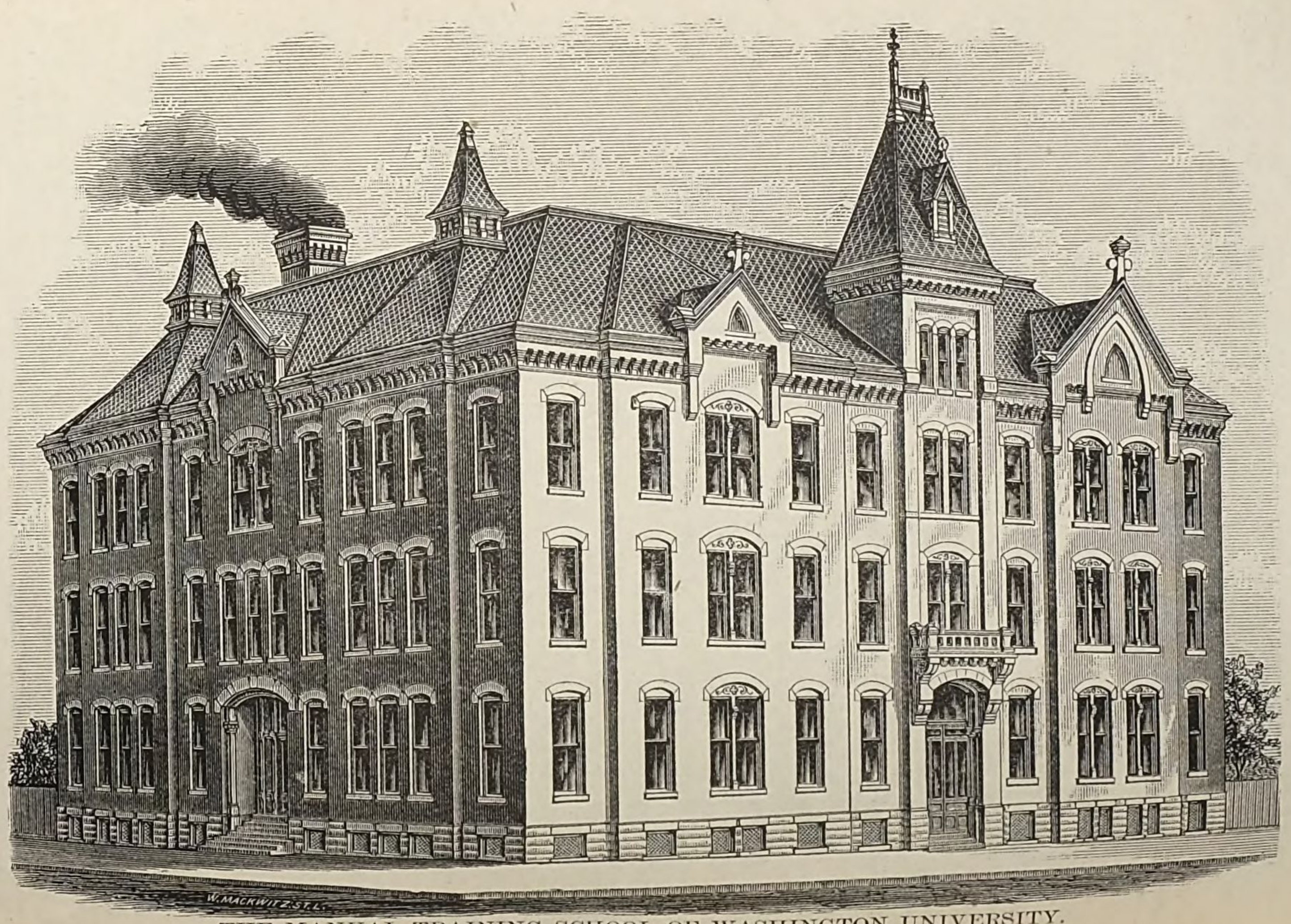
Second year: Algebra through quadratrics, plane geometry, natural philosophy, English history (or Latin continued), English composition and literature, principles of mechanics, penmanship, drawing (line-shading and tinting machines, freehand detail drawing), blacksmithing, and use of machine tools.

Third year: Solid geometry, plane trigonometry and mensuration, English composition and literature, history or French, ethics and political economy, book-keeping, machine and architectural drawing, study of the steam engine, benchwork and fitting, work in the machine shop, and the execution of a project preliminary to graduation.

The course in drawing has three general divisions: First, freehand drawing, designed to educate the sense of form and proportion, to teach the eye to observe accurately and to train the hand to delineate rapidly the forms either of existing objects or of ideals in the mind; second, mechanical drawing, including the use of instruments, geometric constructions, the arrangement of projections, elevations, planes and sections, and the various methods of producing shades and shadows with pen or brush; third, technical drawing, illustrating conventional colors and signs, systems of architectural or shop drawings, and at the same time familiarizing the pupil with the proportions and details of various classes of machines and structures.

SHOPS.

The school has 2 carpenter, 2 turning, 1 blacksmith, and 1 machine shop, each having accommodation for 20 pupils. Four classes of that size can be taught daily in each. Every pupil in the woodworking shops has a set of edge tools for his exclusive use. Other tools, such as squares, hammers, wrenches, &c., are provided for the use of each class in succession.



THE MANUAL TRAINING SCHOOL OF WASHINGTON UNIVERSITY.

[S. Ex. 25——face p. 266.]

Each carpenter shop contains 20 benches, vises, and sets of tools for use in common, a power grindstone, the instructor's desk and bench, settees for the class, and the requisite quota of clamps, glue-pots, &c. A double circular-saw machine is provided for getting out stock ("blanks" for class use) and jobbing.

Each turning shop contains 20 speed lathes, 12-inch swing and 5-foot bed, with complete equipment of face plates, chucks, &c., for 60 pupils; and each shop contains several 8-foot benches for pattern work, a power grindstone, and a moulder's bench and tools for illustrating practically the use and handling of patterns for foundery work.

The blacksmith shop has its full equipment of 20 forges, anvils, tubs, and sets of ordinary hand tools. Ten sets of heavy tools suffice for 20 pupils, as they may work in pairs as "smith and helper." The blast is supplied by a fan blower, and a powerful exhaust fan keeps the shop reasonably free from smoke and gas. In connection with one of the larger forges is a hand-bellows, which can be used when the engine is not running. As every shop exercise lasts two hours, the shop readily accommodates eighty pupils a day.

The machine shop possesses an equipment of 7 engine lathes of 14-inch swing and 5-foot bed; 4 speed lathes; a post drill; a planer, 21-inch by 5 feet; a 25-inch goose neck drill; a shaper of 15 inches stroke; and a large power grindstone. Ten vises and benches, with 40 drawers, afford opportunity for benchwork. It is furnished for a class of 20 students at once. The Corliss engine occupies a part of this shop. It has a 14-inch cylinder and 24-inch stroke, and runs at the rate of 65 revolutions per minute. The engine was built specially for the school by Messrs. Smith, Beggs & Rankin, of Saint Louis. This equipment of steam power furnishes to pupils of the third-year class the means of becoming familiar with such machinery on a scale unsurpassed.

DETAILS OF SHOP INSTRUCTION.

The shop instruction is given similarly to laboratory lectures. The instructor at the bench, machine, forge, or anvil, executes in the presence of the whole class the day's lesson, giving all needed instruction and illustrations. The pupils make notes and sketches as necessary, and questions are asked and answered that all obscurities may be removed. The class then proceeds to the execution of the task, leaving the instructor to give additional help to such as need it. At a specified time that lesson ceases, and the work is brought in, commented on, and marked. It is not required that all the work assigned should be finished; the essential thing is that it should be well begun and carried on with reasonable speed and accuracy.

The shop-training is gained by regular and carefully-graded lessons, designed to cover as much ground as possible, and to teach thoroughly the uses of ordinary tools. This does not imply the attainment of sufficient skill to produce either the fine work or the rapidity of a skilled mechanic; this is left to after years. But a knowledge of how a tool or machine should be used is easily and thoroughly taught. The mechanical products or results of such lessons have little or no value when completed, and they are generally used as new material for more exercises.

In the first place, the main object of one or more exercises is to gain control and mastery of the tool in hand, and not the production of a particular model. The use of the tool may be well taught by a large variety of exercises, just as a knowledge of bank discount may be gained from the use of several different examples. No special merit can be claimed for a particular example; neither can a particular model or series of models have any great value. No good teacher is likely to use precisely the same set twice.

Again, the *method* of doing a piece of work, and not the finished piece, may be the object of a lesson. The exercises by which certain methods of using tools are to be taught often depend upon varying circumstances, such as the quality of the material, the age of pupils, and their knowledge of working drawings.

HOW THE USE OF TOOLS IS TAUGHT.

The tools are not given out all at once; they are issued as they are needed, and to all members of a class alike.

I.—CARPENTRY.

In carpentry work the tools used are the cross-cut, tenon, and rip saws; steel square, try square, bevel and gauge, hammer, mallet, rule and dividers, oil stones, and slips; and among edge tools the jack and smoothing planes, chisels, knife and gouges. Braces and bits, jointer planes, compass saws, hatchets, and other tools are kept in the shop tool closet to be used as needed.

The saw and the plane, with the square and gauge, are the foundation tools, and to drill the pupils in their use numerous lessons are given, varied only enough to avoid monotony. The pupil being able to plane a piece fairly well and to keep to the line in sawing, the next step is to teach him to add the use of the chisel in producing simple joints

of various kinds. The particular shapes are given with the intent to familiarize the pupil with the customary styles and methods of construction.

The different sizes of the same tool, chisels for instance, require different care and methods of handling, and the means of overcoming irregularities and defects in material form another chapter in the instruction to be given. With the introduction of each tool the pupils are taught how to keep the same in order. They are taught that sharp tools are absolutely necessary to good work. To make them realize this is a difficult task.

II.—TURNING.

Five or six tools only are used, and from previous experience the pupils know how to keep them in order. At first a large gouge only is issued, and the pupils are taught and drilled in its use in roughing out and producing right line figures; then convex and concave surfaces; then in work comprising all these—all in wood turning with the grain. A wide chisel follows, and its use in conjunction with the gouge is taught. After this a smaller gouge, chisel, and parting tool, and a round point are given, and a variety of shapes are executed. Next comes turning across the grain; then bored and hollow work. Next, chucking and the various ways of manipulating wood on face-plates, chucks, mandrels, &c. Finally, turning of fancy woods, polishing, jointing, and pattern work.

III.—FORGING.

Work in the blacksmith shop is in one essential feature different from any other kind. Wood or cold iron will wait any desired length of time while the pupil considers how he shall work, but here comes in temperature subject to continual change. The injunction is imperative to "strike while the iron is hot," and hence quick work is demanded—a hard thing for new hands. To obviate this difficulty bars of lead are used, with which the lesson is first executed, while all the particulars of holding and striking are studied. The lead acts under the hammer very nearly like hot iron, and permits of every operation of the blacksmith's shop, except welding.

The various operations of drawing, bending, upsetting, punching, welding, tempering, &c., are learned in connection with the fabrication of hooks, stirrups, chains, swivels, tongs, and other tools.

One of the most difficult lessons in the art of the smith is that of managing the fire. The various kinds of heat are explained and illustrated, and habits of economy of both iron and fuel are inculcated.

IV.—IRON CUTTING.

The course in the machine shop begins with the chisel and the file. The series of lessons in vise work covers chipping and filing. The size, shape, quality, and use of cold chisels are studied as well as their construction at the forge. Large models of drawings are used to show the nature of files, and the various kinds of files are used upon exercises designed to call out their special points.

Then comes the cutting tools of lathes, drills, and planers, and the multiform uses of the various machine tools. The exercises are numerous and greatly varied. They all involve only light work, no attempt being made to teach the manipulation of heavy pieces. A boy accustomed to plan and reason soon learns such things. It can not be claimed that the student workmen become skilled mechanics in any of the shops, though it is insisted that every step shall be clearly understood and fairly executed. The rapid progress of boys to whom all subjects are presented in logical order, with clear and full explanations, and who work under the continual guidance of an expert teacher, and only two hours at a time, during which their interest is fully sustained—the progress of boys under such conditions is most surprising to those who compare the work produced here with the performances of ordinary apprentices of the same number of hours.

STUDY AND MANAGEMENT OF STEAM.

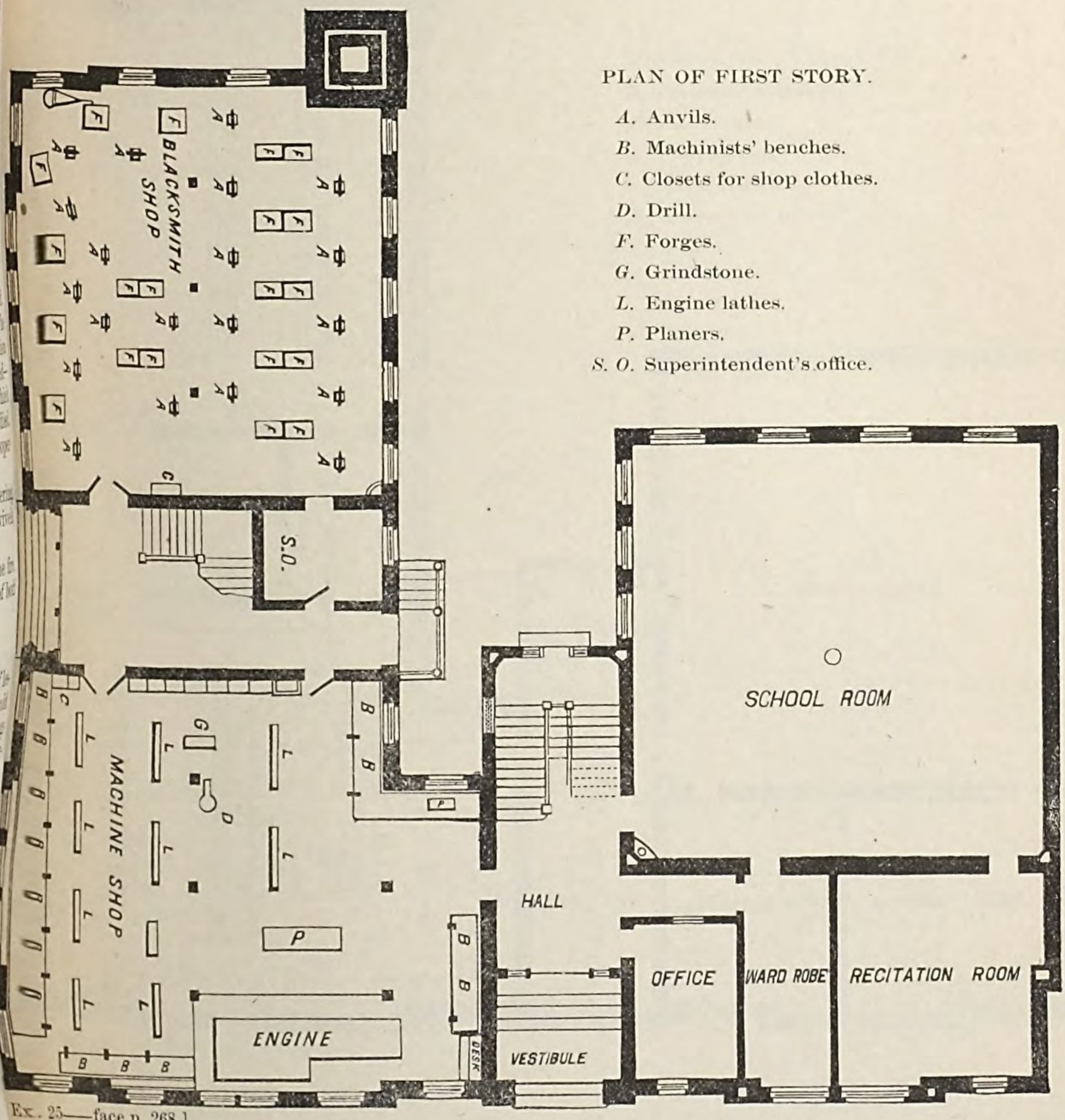
The steam-generating apparatus of the university consists of a battery of three large steel boilers, set and furnished in the most approved manner. These boilers furnish heat for the entire group of university buildings, as well as steam for the engine in the shop. The engine is of the best pattern and superior workmanship, and is capable of about sixty horse-power. During their third year the pupils make a careful study of the engine and furnaces, and are practiced in the management and care of them both.

PROJECT FOR GRADUATION.

Before receiving a diploma of the school, each student must execute either alone or jointly with others, a project satisfactory to the faculty of the school. The project con-

PLAN OF FIRST STORY.

A. Anvils.
B. Machinists' benches.
C. Closets for shop clothes.
D. Drill.
F. Forges.
G. Grindstone.
L. Engine lathes.
P. Planers.
S. O. Superintendent's office.



Ex. 25—face p. 268.]

PLAN OF SECOND STORY.

B. Carpenters' benches.

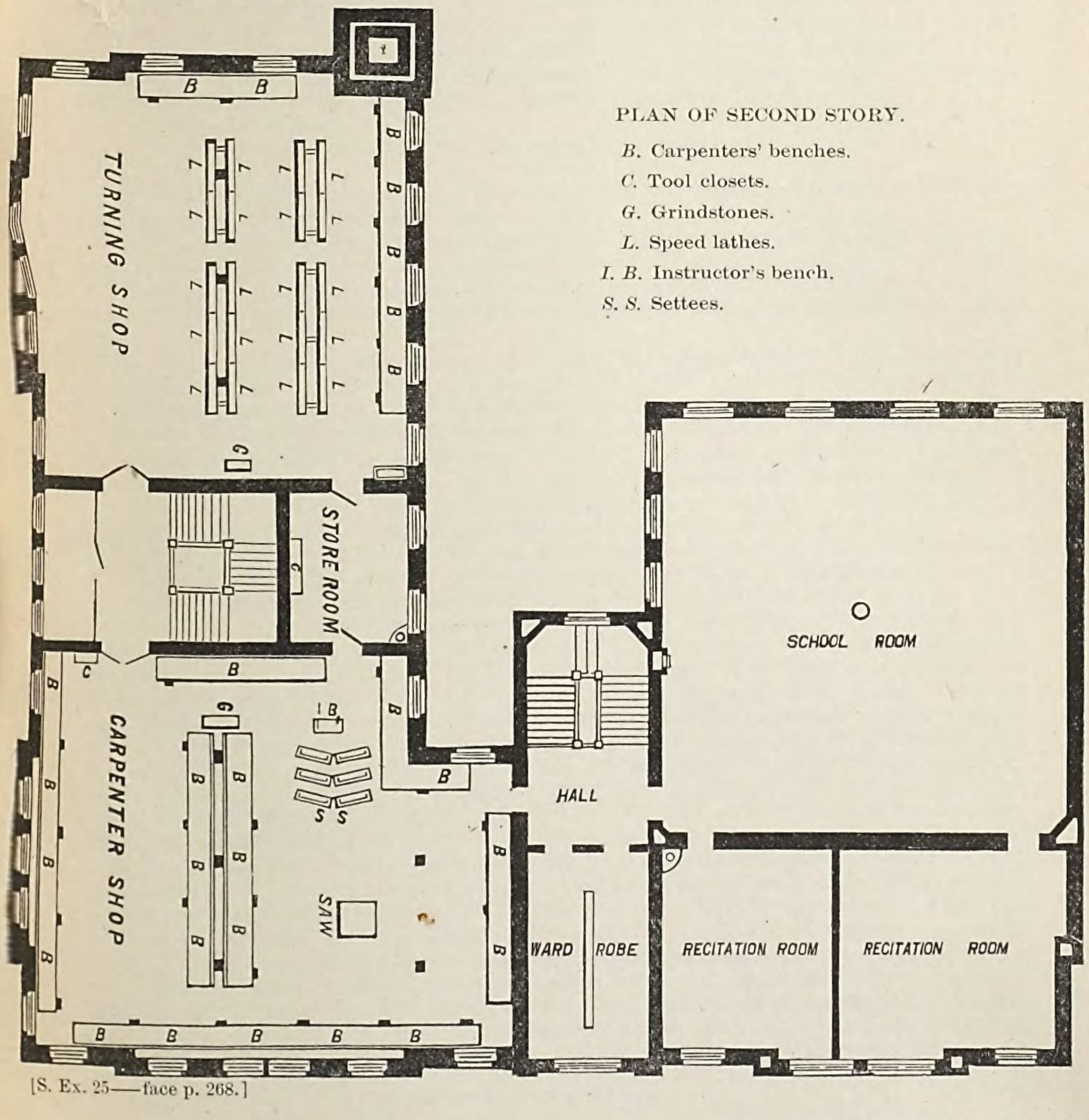
C. Tool closets.

G. Grindstones.

L. Speed lathes.

I. B. Instructor's bench.

S. S. Settees.



sists of the actual construction of a machine. The finished machine must be accompanied by a full set of the working drawings according to which the machine is made. If it is not feasible to construct the patterns for castings of such machines, proper directions for their construction must accompany the drawings.

ENLARGED SCHOOL BUILDING.

A perspective view of the school building and the arrangement of the three floors are shown in the accompanying cuts. It will be noticed that the original building, which has been used for the first two years of the school, is to be henceforth wholly devoted to the interests of shop work, while all needed study, recitation, and drawing rooms are supplied in the recent addition. The enlarged building has a frontage on Washington avenue of 106 feet $4\frac{1}{2}$ inches, and on Eighteenth street of 100 feet.

THE RESULTS OF EXPERIENCE.

The catalogue of Washington University for 1881–'82, issued in December, 1881, also contains the following statement:

The managers of the school are abundantly confirmed in their views as set forth in the prospectus two years ago by the experience of the school during its first year and a half.

From the first the school has been well patronized, and vacant seats have been few; at times every seat has been filled. The school was opened with sixty seats, all for a single class.

The entire number of students enrolled during the first year was 60. The number of seats was increased to 100 during the last summer. The number of students enrolled thus far this year is 102, of whom 42 were members of the school last year.

The zeal and enthusiasm of the students have been developed to a most gratifying extent, extending into all the departments of work. The variety afforded by the daily programme has had the moral and intellectual effect expected, and an unusual degree of sober earnestness has been shown. Success in drawing or shop work has often had the effect of arousing the ambition in mathematics and history, and *vice versa*.

Progress in the two subjects, drawing and shop work (and we had little previous knowledge of what could be done with boys as young as those of the first year class) has been quite remarkable. To be sure there was no doubt of the final result, but the progress has been more rapid than it seemed reasonable to expect. The second year class contains already several excellent draughtsmen, and not a few pattern makers of accuracy and skill. The habit of working from drawings and to nice measurements has given the students a confidence in themselves altogether new. This is shown in the readiness with which they undertake the execution of small commissions in behalf of the school or for the students of other departments. In fact, the increased usefulness of our students is making itself felt at home, and in several instances the result has been the offer of business positions too tempting to be rejected. This drawback, if it can be called one, the school must always suffer. The better educated and trained our students become, the stronger will be the temptations offered to them outside, and the more difficult it will be for us to hold them through the course. Parents and guardians should avoid the bad policy of injuring the prospects of a promising son or ward by grasping a small present pecuniary advantage at the cost of far greater rewards in the future. From the testimony of parents (and by a circular all were invited to give frank expression to their views), the physical, intellectual, and moral effect of the school is exceedingly satisfactory. The *unanimous* response is, an unusual interest and pleasure in school, and very generally an increased fondness for such books and periodicals as the Scientific American. A few boys who had never shown any interest in tools have developed into good and enthusiastic workmen. As a rule the good scholars are the good mechanics.

SUCCESS OF THE RUSSIAN PLAN.

In another important respect our expectations have been more than realized, namely, in our ability to introduce class methods in giving instruction in the theory and use of tools. All divisions in the shops have thus far been limited to 20 pupils, and as a rule all members of a division have just the same work.

The exercises have been two hours long, though often the students have asked for longer work. It is but due to the pupils of the school to say that they have uniformly seconded all efforts looking towards good order and good manners. No little surprise has been expressed by visitors at seeing how quietly and independently twenty boys can work for a couple of hours in the same room. An examination of the rules given below will show the care and consideration expected of all during shop practice. Though all classes handle keen-edged tools, no serious accident has happened, and very rarely have small injuries been received.

COST OF TOOLS.

The cost of our equipment of tools, &c., has been quite heavy, and the generosity of our friends has been put to the test. Over $30,000 have been paid for tools and furniture. It is exceedingly gratifying to the management of the school to be able to report that no call for money for needful apparatus has failed of a favorable response.

REGULATIONS FOR PRACTICE HOURS IN THE WORKSHOPS OF THE MANUAL TRAINING SCHOOL.

"1. When dismissed for shop work, students will go directly to the shop assigned.

"2. During practice hours students must give their undivided attention to the work assigned, not leaving it to clean up till the ringing of the first bell.

"3. All singing, whistling, and lounging on the benches is strictly forbidden; students should talk only when it is necessary, and then in a low tone.

"4. During the regular hours private work can not be permitted. At other times, such work, if of a suitable character, may be allowed, at the option of the instructor.

"5. Students should clean, and return to its place any tool taken from the tool cases as soon as they are through using it.

"6. Promptly upon the ringing of the first bell work should cease; the tools should be put in their proper places, and the bench or machine cleaned, before leaving the room to wash up. Unfinished work should be put in the drawers, or in such places as the instructor may direct. The tool drawers should always be left clean and in order.

"7. Students will be admitted only to such shops as their work calls them, and at the hours assigned, except by permission of the instructor.

"8. The circular saws are not to be used except when specially directed by the instructor.

"9. Students are expressly forbidden to stand around the saw table while the saws are in use.

"10. When directed to use a saw, do not raise it higher than is necessary to cut through the stock.

"11. Avoid passing the hands beyond the saw; use a stick to push small pieces between the saw and the guide. Too much care cannot be exercised in all things pertaining to the use of machines.

"12. When a student has finished the work assigned him, and he sees that the instructor is not engaged, he may go to him for further instructions; otherwise he will remain quietly at his place.

"13. Students must promptly report to the superintendent any loss or breakage of either tools or furniture. Losses and injuries which are the result of gross carelessness or disobedience of orders should be paid for by the students responsible for them."

STATEMENT OF CONDITION SEPTEMBER 27, 1882.

The entire building is completely equipped. It is proposed to admit 100 new pupils annually. This number will diminish to about 80 the second year and 60 the third year. Hence the maximum number of pupils is 240. Ninety new pupils have been admitted the present year. The entire number now in school is 159.

There are nine divisions in the shops. There are 9½ teachers on an average in the school, not including the director, who hears no regular class.

The daily programme of the school is as follows:

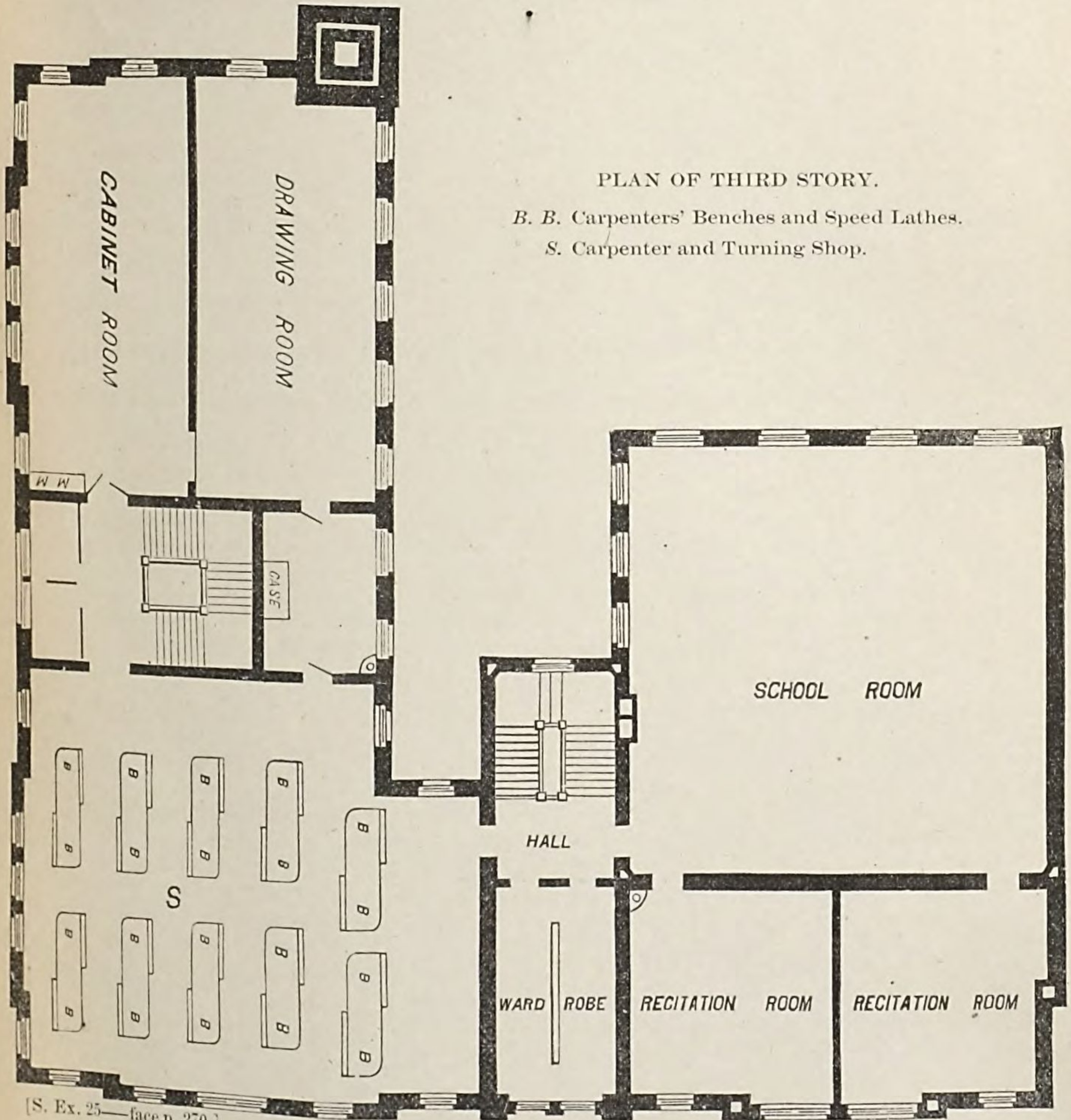
Daily programme.

Class.	Division.	9 a. m. to 11 a. m.	11 a. m. to 1 p. m.	1 p. m. to 1.20 p. m.	1.20 p. m. to 3.20 p. m.
Third year.	A	Physics, geometry.	Machine shop.....	Recess.	French, drawing.
	B	Machine shop.....	Mechanics, geometry.		History, drawing.
Second year.	A	Algebra, physics.....	Blacksmith shop.....		Drawing, English history.
	B	Blacksmith shop....	Algebra, physics.....		English history, drawing.
	C	Algebra, English history.	Blacksmith shop.....		Drawing, physics.
First year.	X	Carpenter shop.....	Drawing, physical geography.		Arithmetic, English grammar.
	R	Drawing, Latin.....	Carpenter shop.....		Arithmetic, physical geography.
	Q	Arithmetic, drawing.	Carpenter shop.....		Physical geography, Latin.
	N	English grammar, physical geography.	Arithmetic, drawing.		Carpenter shop.
	K	Carpenter shop.....	Arithmetic, English grammar.		Drawing, physical geography.

PLAN OF THIRD STORY.

B. B. Carpenters' Benches and Speed Lathes.

S. Carpenter and Turning Shop.



NOTES.—All drawing exercises are one full hour long.

Recitations of third year class are 60 minutes; all other recitations are 40 minutes.

Third year class, A division, have United States Constitution twice in place of physics and once in place of geometry per week.

Whole third year class have English literature once a week in place of French or history.

Second year class have studies in literature once a week in place of history, and composition and spelling in the place of physics.

First year class omit arithmetic, physical geography and English grammar, once a week, to give place for spelling, penmanship, and composition.

APPENDIX D.

SPECIAL EFFORTS FOR THE EDUCATION OF CARRIAGE MAKERS.

NOONDAY CLASS OF CARRIAGE BUILDERS' APPRENTICES AT THE FACTORY OF BREWSTER & CO. (OF BROOME STREET), NEW YORK.

[Description by J. L. H. Mosier, esq.]

In the latter part of January last, while debating with myself what to do to insure success, the happy thought of noon hour studies came to my relief. I would make education compulsory. I began with calling them together for reading only; at a later period I furnished them with paper and caused them to write a full "foolscap" page at home every week, and to present the same to me on Mondays or Tuesdays. I gave each boy a small pass book and instructed them how to keep account of the wages earned by them—simple debit and credit. Later on I gave them simple lessons in perspective drawing. I made the sketches, and to advance my clerk he copied them; each boy receives a copy and six slips of paper; there are five or six sketches. He must copy the sketches on both sides of one slip each week and present them. If he has made sufficient progress when the six slips are filled, we give him advanced sketches to copy; if the reverse, he is kept at the old one until he is perfect. Marks are scored for being late or absent and for a lack of deportment. The reward is one term at the technical school of carriage builders, three nights per week for seven months.

This year I shall introduce arithmetic and a higher grade of bookkeeping. I have also caused them to elect a president, and vice-president, and secretary, and shall also give them a little parliamentary training.

In engaging a boy I give him and his parents a brief outline of what I have here related, and make it a part of the contract, verbal; a failure to comply means dismissal.

Thus far I have met with better success than I anticipated, enough to encourage me in my good work. Brewster & Co. furnish stationery, &c. As class books we have The Hub, Carriage Monthly, and the Blacksmith and Wheelwright, which are given the class, gratis, by the publishers of the journals mentioned.

EVENING CLASS FOR CARRIAGE MECHANICS AT NEW HAVEN, CONN.

[Description by George A. Hubbard, instructor.]

Several years ago, upon coming to this city from Central New York, I found that the construction of carriage bodies was of a decidedly complicated nature, and involved some of the most intricate geometrical problems in the preparation of the plans and drafts laid out for the workmen. Wishing to fathom what were then mysteries to me, I paid an experienced workman for explanations. These were given in so crude and incomplete a manner that I resolved to exert myself and, if possible, establish a class or school where instructions pertinent to the wants of carriage mechanics might be given. With that object in view I have studied during my spare time to get the matter in as simple and clear a form as possible.

Most of the pupils, after a hard day's work, walked about two miles, both in coming and returning from the session. One came from a distance of over three miles, walking most of the time, and was absent only four evenings during the session. When you consider in connection with this exertion the laborious nature of the work performed during the day of ten hours' duration, you will form some idea of the disposition manifested by the pupils to acquire knowledge. The ages of the pupils run from eighteen to thirty-three years, with but two exceptions over twenty years.

Being myself a mechanic and laboring each day, I found the exertion for the session of 1881–'82 too much, and for the session of 1882–'83 I deemed it prudent to form but one class of 12 pupils two evenings a week, the pupils being selected through priority of application, there being in all between 25 and 30 applications for membership. The session opened the first Tuesday in October, and is now proceeding satisfactorily. In the construction of carriages there are brought into practical application artistic designing; mechanical and geometrical drawing; mechanics; knowledge of wood, iron, steel,

cloths, leather, upholstering material, paints, oil, and varnish; chemical action of atmospheric changes upon the different materials used, both in process of completion and in the finished vehicle; draft of vehicles; and, lastly, mechanical skill.

In addition to the annual session I have formed a permanent session, open to all of my pupils, meeting regularly every other Wednesday evening through the year, for the purpose of considering mechanical topics. As an aid I have begun a cabinet of materials entering into the construction of carriages, both in the natural—such as woods and ores—and merchantable form. My library relating to carriages is now one of the best in this country.

[Among the volumes relating to carriages are: Draftbook of Centennial Carriages; Book of Carriage Drafts; World on Wheels, by Stratton; Carriage Builders' Reference Book; History of Coaches, by Thrupp; The Underwork of Carriages, by Budd; Carriage Makers' Manual, by Ware; Carriage Painters' Manual, by Gardner; Construction of private Carriages in England, by Hooper; Coach Body Makers' Guide, by Mattison; The Hub, 11 volumes; Carriage Monthly, 15 volumes; New York Coach Maker, 9 volumes; Harness and Carriage Journal, 2 volumes; Blacksmith and Wheelwright, 6 volumes; Coach Painter, 3 volumes; Le Guide du Carrossier, 3 volumes; Saddlers, Harness and Carriage Gazette, 3 volumes.]

REPORT OF THE COMMITTEE ON TECHNICAL EDUCATION.

PHILADELPHIA, *October* 18, 1882.

To the members of the Carriage Builders' National Association.

GENTLEMEN: Since making our last report to you in Cincinnati, just a year ago, the second term of the Technical School for Carriage Mechanics has closed and the third term fairly opened; and we now have the pleasure of presenting a brief review of the progress of the school during the season of 1881–'82, and of indicating the prosperous beginning which has been made in its work for the season just opened.

The second term opened on October 4, 1881, when the class was removed, together with all the classes of the Metropolitan Museum of Art Schools, to the new and more convenient location at Nos. 214 and 216 East Thirty-fourth street, New York, and continued until May 30, 1882, covering a period of about eight months. Three evening lessons were given each week during the time named, excepting the month of January, when there were two lessons per week. The total number of sessions thus numbered 100, and it is worthy of special note that the instructor, Mr. John D. Gribbon, was never once absent.

The term opened with 26 pupils on the roll (against 22 at the close of season of 1880–'81), which number increased to 40 at the end of October, 47 at the end of March, and 49 at the end of the term. These were divided among the different mechanical departments as follows: 14 journeyman bodymakers, 17 apprentice bodymakers, 2 journeyman blacksmiths, 2 apprentice blacksmiths, 2 journeyman painters, 2 apprentice painters, 1 superintendent, 1 journeyman wheelmaker, and 8 office men.

The widening influence of the school was indicated by the distance from which many of the pupils came in order to utilize its advantages, 29 of the pupils being from New York City, while the remainder were divided among the following localities, namely: Long Island, 7; Newburgh, N. Y., 1; New Jersey, 1; Ohio, 2; Kentucky, 1; Iowa, 1; Massachusetts, 3; Delaware 1; Connecticut, 1; and Canada, 2. Some of the pupils from a distance who were obliged to discontinue attendance were supplied by the instructor with drawings and lesson papers, by which they were enabled to continue their studies at their homes.

It being found impossible for the instructor to attend to the demands of all the pupils, an assistant instructor, Mr. John C. Konrad, was selected from among the more experienced pupils, who rendered valuable assistance to Mr. Gribbon.

The attendance during the second term ranged as follows, namely: During October, 1881, the average number present was 24; November, 24; December, 21; January, 25; February, 18; March, 18; April, 18; and May, 21; or $21\frac{1}{8}$ as the average for the season. The decreased average during February, March, and April was no doubt partly owing to the activity of business in the shops, and the consequent working overtime. The attendance on Saturday nights, however, was unsatisfactory throughout the season, and materially reduced the general average; and we have taken steps to remedy this difficulty by altering the class nights during the present season to Monday, Wednesday, and Friday, by which means it is hoped and expected that the average of attendance will be materially increased. We understand, however, that the above statement of attendance compares favorably with that of other similar evening classes in New York, where the pupils are actually engaged during the day in mechanical pursuits.

Blackboards were provided for such pupils as were sufficiently advanced to make use of them, and creditable working drawings in full size were produced by Messrs. Pease,

Oak, Donovan, Mondin, and Campbell. Some of these drawings have been reproduced in full size on roll paper, and are for your inspection in another part of the building.

The progress of the pupils is thus reported upon by the instructor, Mr. Gribbon, who says: "I consider that the scholars made creditable progress during the second term, taking into consideration the fact that nearly all of them had received no previous instruction in drawing of any kind, or in geometry;" and he adds: "I consider it a great loss to the apprentices that they have not been taught the first principles of geometry in the public schools before trying to learn a trade, for there is so little manual labor nowadays in consequence of the general use of machinery, that a boy requires to be more intelligent and to have a better mental training in order to make a place for himself in the trade than in the days of long apprenticeship."

After due consideration, it was decided to give certificates to such pupils as showed special aptitude and application during the term. The following form was adopted: "Certificate of progress awarded to ———, of ———, for regular attendance, diligent study, and commendable progress, while a pupil in the class in carriage drafting and construction connected with the Metropolitan Museum of Art Schools of New York, from ——— to ———." Twenty-three certificates of this character, printed in attractive form, and duly signed by the committee and the instructor, and also stamped with the seal of the association, were awarded during the second term. Similar certificates will also be given during the current season.

In addition to the one hundred regular class nights, four evenings during the season were devoted to lectures upon mechanical topics, namely: Wednesday, December 7, 1881, lecture by Mr. Chauncey Thomas, of Boston, on "Novelty and expression in design;" Wednesday, January 25, 1882, lecture by Mr. J. L. H. Mosier, of New York, on "Fracture of iron and causes thereof;" Wednesday, March 8, 1882, lecture by Mr. J. L. H. Mosier, of New York, on "Sound and its relation to wheeled vehicles;" and Wednesday, May 17, 1882, lecture by Mr. Howard M. Du Bois, of Philadelphia, on "The whys and wherefores in wheel making," at all of which there was a full attendance of the pupils. The committee owe special thanks to the above named gentlemen for their courtesy in freely giving these interesting and instructive lectures.

The third term for the season of 1882–'83 was opened on the evening of Monday, October 9, when twenty-six pupils were enrolled, the same number as at the beginning of the previous term, divided among the different departments as follows: Bodymakers, 17; blacksmiths, 5; gearmaker, 1; office men, 2; and carriage draughtsman, 1. Various improvements in the working facilities have been introduced during the summer vacation, including a rearrangement of the tables and gas jets, and the introduction of four new blackboards and an additional case in the museum for the reception of models.

The class is continued at the same location as last year, and under the same arrangement with the committee of the Metropolitan Museum of Art, to whom we pay $1,200 annually, and allow all fees received from pupils; in consideration of which a suitable class room is supplied to the carriage class, now second in size and importance in the school, together with lighting, heating, and superintendence, and all necessary working facilities. Mr. John D. Gribbon, by a unanimous vote, has been retained as instructor, and he will be assisted as before by Mr. John C. Konrad. The term will be continued until May 26, 1883, or thirty-two weeks, with three lessons per week, the tuition fee to pupils being placed at the nominal rate of $5 for the season.

It is proposed to continue the series of technical lectures by experts, though arrangements have not yet been perfected for the course; and we take this opportunity of suggesting that any member of the association who feels disposed to address the class on any mechanical subject connected with the trade, or who can assist us to secure the services of any expert known to him, will greatly oblige the committee by communicating with them on the subject, as a growing conviction is felt that such lectures can be made an important and valuable feature of the school work.

The committee would also invite your attention to the need of increasing the working facilities of the school by making constant additions to its technical library and museum. Accessions of some importance have been made during the past year to both these departments, special acknowledgment being due to Mr. J. L. H. Mosier and his associates connected with the Brewster Carriage Works, Broadway and Forty-seventh street, New York, for a gift of 36 volumes; and to Mr. H. M. Du Bois, and Messrs. Hoopes, Brother & Darlington, for specimens of wheels and parts of same. The usefulness of the library would be largely increased if many of the pamphlets, periodicals, and collections of carriage drawings should be bound into volumes, and it is hoped that a sufficient surplus will be derived from your subscriptions this year toward the school fund to authorize the committee not only to forward the work of binding, but also to purchase many additional text books and works of reference, the need of which is now keenly felt. To better illustrate the requirements of the school in this regard, and to enable you to judge of what has already been accomplished in this direction and to perceive what further con-

tributions will be most acceptable, a printed catalogue of the books, pamphlets, and periodicals now in possession of the school will be distributed among the members of the association at this convention; and gifts of any additional works of technical interest which the study of this catalogue may suggest to you are earnestly invited.

We also take the liberty of suggesting that any of the parts of carriages exhibited by the members of the association at this convention which exhibitors may feel disposed to present to the school will be thankfully received by the committee and duly deposited in the museum of models.

Before closing this our annual report we take pleasure in alluding to the successful continuance of two similar classes for the instruction of carriage mechanics now in successful operation in New Haven, Conn., and New York City, namely: Mr. George A. Hubbard's class for carriage draughtsmen, in New Haven, and Mr. J. Polya's class for carriagebody makers, at No. 1295 Broadway, New York. We are pleased to learn that both these classes have met with marked success during the past year, and that courses of study similar to those already pursued will be continued during the present season.

Respectfully submitted.

Signed by the committee on technical education:

JNO. W. BRITTON, *Chairman.*
WILDER H. PRAY, *Treasurer.*
WM. D. ROGERS.
LOWE EMERSON.
CHAUNCEY THOMAS.
WM. N. FITZ GERALD.
GEO. W. W. HOUGHTON, *Secretary.*

REPORT OF THE TREASURER OF THE TECHNICAL SCHOOL.

SUMMARY.

Total single subscriptions	$3,770 90
Total yearly subscriptions	5,520 00
Paris scholarship	500 00
Grand total	9,790 90
Amount due and unpaid	405 00

RECEIPTS.

Single subscriptions	3,790 90
Yearly subscriptions	3,325 00
Paris scholarship	500 00
Interest on deposits	142 31
Rebate on school payments	11 15
Total receipts	7,769 36
Total disbursements	4,432 83
Cash on hand	3,336 53
	7,769 36

RESOURCES.

Cash on hand	3,336 53
Subscriptions due and not paid	405 00
Subscriptions not due	1,620 00
	5,361 53

APPENDIX E.

SCIENTIFIC INSTRUCTION IN WELLESLEY COLLEGE; THE INDUSTRIAL TRAINING OF WOMEN IN LASELL SEMINARY, THE IOWA AGRICULTURAL COLLEGE, AND THE ILLINOIS INDUSTRIAL UNIVERSITY; A HISTORICAL SKETCH OF THE NEW YORK SCHOOL OF COOKERY; THE WORK OF MISS MARIA PARLOA AS A TEACHER OF COOKERY; "COOKING SCHOOLS IN THE SOUTH; AND THE NEW CENTURY EVENING CLASSES FOR WOMEN."

Course of Instruction in Science in Wellesley College.

The scientific course is arranged for students who desire to give the four years of college life to the pursuit of the natural, physical, and mathematical sciences and the studies necessarily connected therewith. The course as laid out gives opportunities for scientific study which are substantially the equivalent of those given to young men in the best scientific and technical schools.

In the department of chemistry and mineralogy there are two laboratories, a lecture room, and a storeroom for apparatus. The chemical laboratory is furnished with apparatus, cupboards, and drawers for ninety-six students, working in divisions. The desks are furnished with sinks, gas, and hot and cold water. The laboratory is provided with a number of convenient hoods for manipulation of noxious gases.

After studying chemistry a year, the students commence the course in mineralogy. This embraces the various topics comprehended under morphology, the physical properties of minerals, and the chemical reactions employed as tests. In the mineralogical laboratory every convenience for blowpipe analysis is provided. From 20 to 30 determinations (according to Brush) are required. Students can also determine as many other minerals as they desire.

Throughout the course they study minerals, and become familiar with their chemical and physical properties by careful observation and comparison, with the aid of the blowpipe, the microscope, and chemical reagents. They have access to the cabinet collections and use specimens in the class room.

The study of crystallography is taken up in connection with mineralogy. This is aided by a collection of models of crystal forms and a collection of typical crystals.

The study of lithology follows. There is a large collection of rocks specially arranged for this course. An important branch of this study is carried on with the aid of the compound microscope, the polariscope, and a collection of microscopical sections of typical rocks and their constituent minerals.

The department of physics occupies a convenient lecture room, with lantern and *porte-lumière* constantly in place for the illustration of lectures or the projection upon the screen of minute experiments. Water, wires from the battery, oxygen and hydrogen, and illuminating gas are furnished at the lecturer's desk. There are a professors' laboratory, for the preparation of experiments, and an extensive students' laboratory, supplied with instruments for quantitative work. One dark room is supplied with a Bunsen's photometer for measuring the candle power of lights, and with apparatus for spectrum analysis, &c. Another room is fitted up for an electrical laboratory, and supplied with a Wheatstone's bridge and resistance coils, Thomson's mirror galvanometer and lamp stand, and other apparatus necessary for electrical measurements. There is also a battery room and a room for photography.

Physical astronomy is an elective study of the senior year. The basis of instruction is given by lectures, illustrated by globes, charts, and lantern slides. The lectures are supplemented by the constant use of the works in the astronomical library and by observations with the telescope. Every student is required to observe the moon at several phases, and to identify certain prominent craters and seas; also, to observe the sun and planets and certain nebulæ and clusters. Especial attention is given to spectroscopic astronomy and the constitution of the sun.

In botany instruction is given by recitations, lectures, and by practical work in the laboratory. Compound microscopes are furnished by the college for the use of all the

classes. The students have access at all times to the herbarium and the botanical library. Plants from the greenhouse are supplied during the winter.

In biology the full course extends through two years, and consists almost entirely of laboratory work. Every student is provided with a microscope and two or three objectives. The laboratory possesses lenses of the highest power, and each student is furnished with a complete set of dissecting instruments, and a case of twenty reagents and coloring fluids for testing the nature and properties of the objects studied. After a lecture upon the subject of the day, the students repair to their respective tables, each of which is provided with the organism or tissue to be studied. Drawings are made of their dissections and preparations, and these are accompanied by written descriptions, together with notes of physiological action, &c.

There are in constant use in the different scientific departments 65 microscopes of various patterns, according to the work to be done; also a microscope especially adapted to the study of rock sections, and a polari-microscope. There is a large battery of objectives, ranging in power from 1.25 inches down, and a variety of accessory apparatus.

There are, in addition to the general library of 20,000 volumes, five special libraries, viz, the botanical, that of biology and zoölogy, the chemical, that of the physical department, and the Gertrude library for biblical study. A large reading room is also supplied with newspapers, periodicals, and more than a hundred literary reviews and magazines, and the best scientific journals of every kind published in the United States, England, Germany, and France.

INDUSTRIAL TRAINING IN LASELL SEMINARY, AUBURNDALE (NEAR BOSTON), MASS.

Thorough instruction in cooking has been given in this school for six years by Miss Parloa and Mrs. Daniels, of Boston, and for five years lessons have been given in dress cutting and fitting, after Taylor's system, and in millinery by experienced city workers. The primary object has been to qualify the pupils to supervise every department of home interests; to present them in an attractive aspect; to elevate them to their true place, as likely to be in any well ordered home most important prerequisites in the fulfilment of duty. At the same time the instruction is so thorough technically as to be available if necessary for any service. Classes are formed in each branch of work, in which the pupils are demonstrators, the teacher supervising if more special instruction is desired. Both these and the general lectures are entirely apart from the domestic department of the school, as in the chemical lectures or other laboratory work, which they follow in general style of presentatio...

Miss Parloa's lessons given on Saturday afternoons, were free, and attended by the whole school. A programme for the entire course of lessons is issued at the beginning of the year, each lesson containing a variety of substantial and dessert dishes. Miss Parloa prepares these at a table on a low platform, and cooks, as may be necessary, at a stove on the same platform, in near view of her audience, explaining as she works. The various dishes disappear in an assembly of school girls ready with spoon and napkin, as well as with note book; and the whole bears the appearance of a recreation rather than a task. The interest has been surprising, even to those who had the most sanguine faith in ultimate success. The circular issued for this year contains extracts from notices by the press in every part of the country, representing every variety of interest, and expressions from the homes to which the pupils belong of great gratification with the interest awakened and the success in repeating the processes learned at school.

The dressmaking work is done by the pupils themselves, in classes of six, in one of the usual recitation rooms. At the junior socials fair hostesses have received their invited guests in dresses fitted and made in connection with this class, entertained later in the chapel with the usual literary exercises, and led the way to a tastefully arranged table, where they served sandwiches, a variety of delicious cake, coffee, and ice creams, entirely the work of their own hands.

As we learn, recently a whole side of beef was cut up, as furnished for the best private tables, and a thorough lesson given in the uses and prices of the various pieces. It is a part of the plan to impart practical knowledge of materials in market and shop, to encourage the development of judgment and skill for all the needs of household life.

A little time steadily given through a year to the cultivation of practical intelligence in these matters is found to detract in no way from the usual school requirements, while it builds a broad, easy way over the gulf which lies for many a girl between her school and her married life.

"My daughter has improved in so many ways," is a frequent comment of mothers. "She has brought home an interest never apparent before in all our home work." This is what was most desired to bring the girl's mind into relation with life as it is likely to be for her, to bring her highest scholarly acquirements to enrich her home life.

The principal is more than satisfied of its practicability, and so much considers the experiment an established and gratifying success that a practice kitchen and dining room, with all appliances of the best cooking schools, were provided in the new wing added last year.

In all the departments of home instruction there is eager interest on the part of pupils and assurance of the best success.

Department of Domestic Economy in the Iowa Agricultural College, Ames.

[By Mrs. Mary B. Welch, lecturer on domestic economy.]

The first instruction in this department was given in 1872 by a course of lectures to the junior girls on matters connected with housekeeping. In 1877 the trustees added a course in cooking, and provided and furnished a kitchen for the use of the class. For the last four years, therefore, lessons in cooking have been given to the junior class, in connection with lectures on such subjects as house furnishing, care of the sick, care of children, management of help, dress, &c. Physiology and domestic chemistry are carefully taught as a part of the course in domestic economy.

In 1879 the course was further extended by the addition of sewing and laundry work. These have been taught with fair success for two years. Many of our students, however, have been able to pass them by examination, and it was found difficult to arouse the same degree of interest in either as in cooking. There has been a steadily increasing demand for instruction in the latter, and the course has been reorganized for this year so as to give the cooking lessons to a larger number of students. These lessons were formerly confined to the juniors, on account partly of want of room in the small kitchen provided by the board, and partly on account of lack of drill in chemistry in the preceding years. At the last session of the legislature larger rooms were assigned to the department, and the present plan arranges for progressive lessons to the freshman, sophomore, and junior classes.

The young women of the freshman class prepare, under my instruction, the noonday meal for one table in the main dining hall, where two hundred students are boarded. The housekeeper furnishes the bill of fare for the day, and sends to the practice kitchen sufficient material for a dinner for ten persons, which is cooked and served by the teacher and her class. Not more than five work at once, and thus each receives careful supervision and can get actual practice at every lesson. In this way the class is taught plain cooking—how to prepare meats, vegetables, and simple desserts. The dinner cooked at the last lesson is a fair sample of the daily work. It consisted of roast beef, mashed potatoes, stewed tomatoes, and apple dumplings. While the work was going on the teacher explained not only the culinary processes, but told the class also something about the value of beef as a food, the best cuts, how to tell good beef from poor, the marks of disease, something also about the history and food value of the potato and apple, the tests for good flour, and the composition and action of baking powder.

In order to get time for this minute instruction to so large a number, the laundry work and sewing were necessarily abolished and the sophomores are given the lectures, which have been extended to embrace not only those matters which relate strictly to housekeeping, but more comprehensive information on hygiene, the laws of good breeding, and those things which go to make a home beautiful as well as clean and convenient. The class is required to take notes, and in connection with the lectures do a good deal of careful reading and write several essays each on the topics treated of.

Finally, to the juniors is given a more elaborate course in cooking. Great pains is taken in that year to explain as carefully as may be the nutritive value of different foods, tests for adulterations, the combination of the several classes of food in bills of fare so as to be most valuable, &c. Together with the theory is given thorough practice in both plain and ornamental cookery. Bread and soups are made the subjects of special drill, while salads, side dishes, pastry and cake, carving, boning, and garnishing are also most thoroughly taught. A few lessons are given in the preparation of food for the sick, and these are dwelt on with special emphasis.

The interest of the students in the department of domestic economy has been constant and lively, while the board of trustees, the college faculty, and the patrons of the school have united in encouraging its development. It is acknowledged to have met a long-existing want and to have done real service to the young women of the State. It has not only given them manual skill, but it has also increased their respect for all branches of such labor, and added dignity to that part of their life work hitherto considered as menial drudgery. The promise for the future is most encouraging. Stimulated by the enthusiasm of her pupils, strengthened by the good will of her fellow teachers, and aided by the generous appreciation and liberal policy of the board of trustees, the teacher of domestic economy looks forward with sure faith to the fullest development of her department.

The School of Domestic Science of the Illinois Industrial University.

[By Mrs. John M. Gregory.]

This school was formally opened in Urbana, 1874, being the first college course of high grade in domestic science organized in the United States, if not in the world. With no precedent to guide, few or no text books on the subject to furnish material aid, with an incredulous public opinion to contend against, and opposition in most unexpected quarters to meet, the undertaking at the outset seemed formidable enough. But the six years that have intervened have sufficed to overcome many obstacles and demonstrate the practical value of the work.

The school was the outgrowth of a conviction that a rational system for the higher and better education of women must recognize their distinctive duties as women—the mothers, housekeepers, and health keepers of the world—and furnish instruction which shall fit them to meet these duties.

As set forth in the catalogue, it was the aim of the school to give to earnest and capable young women a liberal and practical education, which should fit them for their great duties and trusts, making them the equals of their educated husbands and associates, and enabling them to bring the aids of science and culture to the all important labors and vocations of womanhood.

This school proceeded upon the assumption that the housekeeper needs education as much as the house builder, the nurse as well as the physician, the leaders of society as surely as the leaders of senates, the mother as much as the father, the woman as well as the man. We discarded the old and absurd notion that education is a necessity to man, but only an ornament to woman. If ignorance is a weakness and a disaster in the places of business where the income is won, it is equally so in the places of living where the income is expended. If science can aid agriculture and the mechanic arts to use more successfully nature's forces and to increase the amount and value of their products, it can equally aid the housekeeper in the finer and more complicated use of those forces and agencies in the home, where winter is to be changed into genial summer by artificial fires, and darkness into day by costly illumination; where the raw products of the field are to be transformed into sweet and wholesome food by a chemistry finer than that of soils, and the products of a hundred manufactories are to be put to their final uses for the health and happiness of life.

The purpose was to provide a full course of instruction in the arts of the household, and the sciences relating thereto. No industry is more important to human happiness and well being than that which makes the home. And this industry involves principles of science as many and as profound as those which control any other human employment.

In the fall of 1874 the writer of this article was called to take charge of this school, which then existed only in name. During the first year she gave much time to mapping out and preparing a course of study, which was presented for the first time in the catalogue of 1875–'76, substantially as follows:

COURSE OF DOMESTIC SCIENCE

Required for degree of B. S. in school of domestic science.

FIRST YEAR.

1. Chemistry; trigonometry; drawing (full term); British authors.
2. Chemistry; designing and drawing; American authors.
3. Chemistry; designing and drawing; rhetoric.

SECOND YEAR.

1. Botany; physiology; German or English classics.
2. Food and dietetics (simple aliments); botany and greenhouse; German or English classics.
3. Food and dietetics (compound aliments and principles of cooking, &c.); zoölogy; German or English classics.

THIRD YEAR.

1. Domestic hygiene; ancient history; German or French.
2. Physics; mediæval history; German or French.
3. Physics or landscape gardening; modern history; German or French.

FOURTH YEAR.

1. Household æsthetics; mental science; history of civilization.
2. Household science; constitutional history; logic.
3. Domestic economy; usages of society, &c.; political economy; home architecture; graduating thesis or oration or essay.

It will be seen in the above that the technical studies do not begin until the second term of the sophomore year. There are two reasons for this arrangement: First, the very evident one that the applications of a science must be preceded by and based upon a knowledge of the theory and general principles of that science. For instance, no truly scientific study of food and dietetics could be entered upon until the pupils had acquired a knowledge of general chemistry, qualitative and quantitative analysis, as also some knowledge of plant structure, and skill in manipulating the microscope. A second reason for placing the technical studies late in the course is that the students may bring to this work greater maturity of mind.

No other one science is more constantly applicable to the necessities of every-day life than chemistry. Hence it was made a prominent feature of the course, either under the form of general chemistry with laboratory practice, or in the study of foods and their analysis. Moreover, laboratory practice is calculated to develop that patient, careful attention to minutiæ, and appreciation of exact weights and measures, which is quite as essential to definite results in the kitchen as in the laboratory. A habit of searching for the causes of failure, formed in the laboratory, will yield good results in the kitchen. George Eliot makes one of her characters in "Adam Bede" say: "A woman will make porridge every day for twenty years and never think of measuring the proportion between the meal and the milk; a little more or less she'll think doesn't signify. The porridge will be awkward now and then; if it's wrong, it's something in the meal, or it's something in the milk, or it's something in the water. Look at me; I make my own bread, and there's no difference between one batch and another from year's end to year's end; but if I'd a woman in the house I must pray for patience at every baking of the bread if it turns out heavy. It's an impious, unscriptural opinion to say a woman's a blessing to a man now; you might as well say that adders and wasps are blessings, when they are only evils belonging to this state of probation." Not so bad as that, Mr. Massey. She simply needs to be educated. Man's contact with the world has taught him to give "pounds and ounces as to quantity," where woman gives only approximative handfuls.

The other corner stones of the course are anatomy, physiology, and hygiene. No other acquisitions can atone to young women for the lack of a thorough practical knowledge of these. Woman, much more than man, has suffered from lack of proper instruction in school courses in these vital sciences.

Mathematics is required in the course only through trigonometry, this being as far as required by any subsequent study in the course, and as far, in all probability, as will be needed by young women in after life.

TECHNICAL STUDIES.

The work in the technical studies was necessarily conducted by lectures, class demonstrations, and readings. The students were thus made acquainted with the best literature on the subjects treated. The university library, with its wide range of carefully selected scientific works and annual appropriations for the purchase of new books, afforded excellent opportunities for the students to consult authorities.

Food and dietetics.—This study occupied two terms. The work began with a study of the simple aliments, such as *starch*, the structure of its grains in different plants, shown by the microscope; test, action of heat, water and other agents upon it; digestibility and dietetic value; *sugar*, kinds, sources from whence obtained; tests, relative sweetening values, processes of manufacturing and refining; effects of heat, acids, and other agents upon it, and means of judging quality; dietetic value. The hydrocarbons, the nitrogenous group, and saline principles were studied in the same manner, care being exercised to bring into prominence, appropriately grouped, all the physical and chemical properties having a practical bearing upon the preparation of foods to secure their highest dietetic value.

This preliminary work prepared the students for the more complicated study of the compound aliments and the general principles of cooking and dietetics. The *cereals* furnished the themes for a number of instructive lectures. The structure of the wheat grain was shown under the microscope, and also by means of one of Doctor Auzoux's admirable *papier mâché* models. A knowledge of the physical properties and composition of the different parts of the grain made clear the transformations produced in the processes of grinding and bolting, and showed the comparative nutritive value of the different products of milling. This was followed by lectures on bread-making by fermentation

and by the use of chemicals, the advantages and disadvantages of the two methods. The yeast plant was studied under the microscope, and the effect of different temperatures upon it noted. The qualities of good bread, the chemical transformations that take place in rendering the dough light, the temperature required for baking, the methods of determining the temperature of the oven, the digestibility of bread as influenced by its freshness, lightness, and sweetness, and other related topics, were subjects in which the students became much interested. They often expressed great pleasure and surprise to find so many and such profound principles of science bearing upon so common an art as bread-making. They left the subject, no longer to regard the difference between good and bad bread as a matter of "luck," but as dependent upon the intelligent application of scientific principles; principles as much under human control as are those which regulate the action of a steam-engine. The world readily concedes that knowledge is essential to success in controlling a locomotive, but it is slow to see that it is equally essential to success in the management of a bake oven. In a little, well-directed study of the chemistry and philosophy of bread-making may be acquired useful principles that women are left to find out for themselves, as a rule, through experience, which, too often, means months of sad failure and impaired health.

We are apt to regard the common vegetables of our gardens as devoid of interest and unworthy of study. This is because of our ignorance. Take for example the Irish potato (*Solanum tuberosum*). Look into its history, study its chemistry and philosophy, and what a volume of political economy, national destiny, practical truth, and anecdote is opened up. From a mere curious exotic planted in Sir Walter Raleigh's garden in 1586, so disappointing that he ordered his gardener to "pull up the worthless weed," it becomes one of the most widely diffused plants, struggling for existence even within the arctic circle. It has added millions to the populations and wealth of Europe. A single failure of the potato crop left Ireland in a famishing condition, reducing its population, it is said, from eight or nine millions to five millions. The potato famine in Ireland was but one of Heaven's great hygienic teachers, confirming two great natural laws, viz.: 1. Rotation of crops. Plants long cultivated on the same soil fail at least. 2. Variety in diet. Long ago it was written "Man cannot live by bread alone." This contains a dietetic as well as a spiritual truth, even more applicable to the potato than to bread.

The discussion of the potato and other vegetables common upon our tables, afforded many a topic of as much interest as importance. The composition, chemical changes in cooking, various methods of preparation, and dietetic uses and value were thoroughly studied.

The potato is defective in nitrogenous principles, fat, and mineral matter. In this is to be found an explanation of the enormous consumption of potatoes by the Irishman.

Tea, *coffee*, and *cocoa* furnish topics for a number of practical lectures, treating of the different kinds, their comparative values, composition, properties, effects upon the system, &c. The best way to teach one how to make good coffee is to begin by teaching the properties of its constituent principles. This known, good results are insured or failures will be speedily corrected. For example, know that the peculiar aroma upon which the goodness of coffee so largely depends is dissipated by long boiling or continued exposure to the air and one will not make the common mistake of roasting, grinding, and leaving coffee long exposed to the air before using, or allowing it to boil until the aroma is dissipated and the residuum but a bitter dose.

That questionable food, alcohol, was impartially considered in the light of the latest and most reliable scientific investigations, and the highest authorities were questioned in regard to its effects upon the system in extremes of heat, cold, hunger, severe mental or physical labor, its medicinal value, &c.; and then all the force of moral considerations was brought to bear upon this instrument of evil that so baffles scientific certainty, that is so delusive in the exquisitely cut wine-glass, this will-o'-the-wisp that lures men on to ruin and is the direct or indirect cause of so many woes.

The time has come when women should be educated for battle with king alcohol. Young, impressible womanhood must drink from the springs of learning, that their eyes may be opened to a full realization of the nature and strength of this evil, to a perception of its chief strongholds and its vulnerable points. They must be led to see that prenatal influences are largely responsible for the intemperance of the world; that bad bread, unwholesome food, insufficient nutrition, and improperly selected diet create a want in the system, which, not being understood, often seeks gratification in the wine cup. We shall never get the upper hand of intemperance until we have gone back of the saloons, in search of the causes that gave it birth; till we have entered the homes, and taught those who preside over them the strong moral influences exerted by good bread, wholesome food, and healthful, attractive homes. Says an English philanthropist of extended observation, "The more we investigate the social evils of the day, tracing them to their causes, the more convinced shall we be that reform to be healthful must proceed from within rather than from without. If we wish to purify and elevate the

national life we must begin, therefore, in the home. And if we wish to reform the homes of the people we must train aright those who for good or for evil will preside over them."

Animal foods open up a wide field for interesting study and research. The importance of a mixed diet, the composition and nutritive value of different meats, the average market price and economical value of different parts of the beef, methods of cooking with reference to comparative economy and healthfulness, temperature required, means of judging of the quality of meat, the use of the microscope in detecting the presence of trichina and other parasites, thorough cooking as a safeguard against these parasites, and its antiseptic action when meat is tainted, were among the topics discussed, and are sufficient to show the magnitude and importance of the subject.

We need no better argument for the importance of instructing the people on these subjects than is furnished by the official reports of the enormous quantity of diseased and unwholesome meat that annually finds its way into the markets, in spite of health officers and inspecting boards. Boards of health, however vigilant, will labor with tied hands until they find in educated housekeepers efficient colaborers.

Milk, a typical food, its analysis, examination under the microscope, varying composition as influenced by breeds of cows, their treatment, and food, and by climate, &c., the philosophy of butter making, temperature for setting the cream and for churning, importance of cleanliness, duration of churning, working, washing, and salting butter, and other related topics were discussed.

When it is so comparatively easy to make good butter it seems a pity that ignorance should be allowed to serve us a dyspeptic article. But many a farmer's wife does not know what good butter is, much less the methods of producing it.

FOOD MUSEUM.

To aid in this study of food and dietetics, the nucleus of a food museum was begun, with the purpose of developing it, when the requisite funds could be secured, somewhat on the plan of the food collection of the Bethnal Green Museum, London, where the labors of Playfair, Huxley, Frankland, and Church are doing so much to instruct the public in this hitherto neglected department of education. The London food collection is a grand object-lesson on the materials and processes of every-day life to the multitudes who visit it. Specimens of all the important human foods are gathered from the various quarters of the globe, and the composition of the most important foods is shown by what is termed "displayed analyses," enabling the eye to take in at a glance the relative proportion of the various constituents of a given food.

Colored charts, drawings, and diagrams attract the eye and fix the attention, teaching even the most illiterate useful lessons on the composition and physiological functions of foods, and guarding them against adulterated and spurious articles. Numerous water analyses are so shown as to enforce the necessity for pure drinking water. Filters of different kinds and the materials used in their construction are exhibited, and the actual process of filtering through sand, gravel, and charcoal is displayed. In short, in every department of this great museum the endeavor has been to make the food collection tell its own story in a most forcible and practical manner. It is a matter of reproach to the United States that hitherto little or nothing in this direction has been done here, either in a public or private way.

It was also the as yet unfulfilled purpose of the school of domestic science to have a kitchen museum, fitted up with the most approved modern conveniences, partly for experimental purposes in connection with class lectures and partly as a means of illustrating the most convenient arrangement for a kitchen, showing the great economy in time and strength that would result from having kitchens properly planned and arranged.

Hygiene.—In addition to the study of advanced anatomy and physiology, this school provided for its young women a special course of lectures, extending through a term, on the hygiene of the home, embracing such topics as the location of dwellings, good drainage, uncleanliness as a cause of disease; the necessity for good ventilation, pure water, and abundant sunlight; bathing, exercise, and other conditions of health; the construction, material, and hygiene of dress; the principles of nursing the sick. Lectures were also given on the anatomy, physiology, and hygiene of the female pelvic organs, under the conviction that it is through the want of this knowledge that so many women become confirmed invalids. The teacher, delicately, cautiously, prayerfully, and with reverential tread, endeavored to lead her pupils into paths which show the grander possibilities for humanity through an enlightened motherhood. The young women were taught to look upon disease as the penalty for disobedience to inexorable natural laws; that among the many causes which combine to rob woman of her birth-right, good health, one of the most potent is her very unhygienic dress. And it was not found impossible to secure, if not a radical, at least a very sensible reform in the dress of the members of the class.

From one-seventh to one-fourth of all children both fail to pass their first year, and 25 to 40 per cent. perish before they have completed their fifth year, we are told.

We appeal to physicians to stay this terrible "slaughter of the innocents," but with a grave shake of the head they tell us they are all but powerless in the matter, and that our future hope must look mainly to a more enlightened motherhood. But, full of old time prejudices, we are slow to act. Says Rev. Charles Kingsley, "Would to God that some man had the historical eloquence to put before the mothers of England the mass of preventable suffering, the mass of preventable agony of mind and body which exists in England year after year; and would that some man had the logical eloquence to make them understand that it is in their power, in the power of the wives and mothers to stop, as I believe, three-fourths of it."

What is true of England is true of America.

"To tens of thousands that are killed add hundreds of thousands that survive with feeble constitutions and millions that grow up with constitutions not so strong as they should be, and you will have some idea of the curse inflicted on their offspring by parents ignorant of the laws of life."—(Herbert Spencer.) Is anything more needed to show the importance of introducing into courses of study for girls the lectures outlined above?

The following is from a board of health report: "The records of infant mortality offer a melancholy illustration of the necessity of the mother's previous preparation for the care of her children. The first-born die in infancy in much larger proportion than their successors in the family. The mother learns at the cost of her first child, and is better prepared for the care of the second, and still better for the third and fourth, whose chances of development into full life and strength are much greater than those of the oldest brothers and sisters." "Think of the mother learning 'at the cost of her first child,' and of the absurd young mother learning beforehand, and choose between. Also, please compare the 'previous preparation,' here recommended with the mere bureau-drawer preparation which is the only one at present deemed necessary." (Mrs. Diaz.)

What knowledge can be of higher value than that which "aims to render growth more perfect, decay less rapid, life more vigorous, and death more remote," by the control it gives over the causes of disease? Strange that the question should need asking. "Stranger still that it should need defending," says Herbert Spencer.

All are ready to concede our need of a physical reformation, but few are prepared to do anything to bring it about. Only physicians seem to have any just conception of the great number of preventable diseases that year after year are desolating our homes. Not until our schools and colleges shall more generally unite their efforts with those of physicians and health boards, can we hope for any very marked progress in sanitary reform. If women were properly educated they could do in this sanitary work what cannot be done by men.

Within the last few years sanitary science has attained proportions too vast to admit of its being summarily disposed of in the meager "hints on health" usually appended to text books on physiology. Physiology and hygiene are sciences so vast in importance and extent as to merit being more generally dignified in colleges by separate professorships.

Especially do girls need to have the gospel of good health preached to them and lived before them daily. It cannot be true that Michelet is right when he asserts that women are essentially diseased. It cannot be true that the Divine Architect, every where else so wise a builder, so accurate in His estimates, so judicious in apportioning means to their ends, has here alone made the burden too heavy for the support, the aspirations too great for the capacities. It may be true that at present disease is the rule among women and health the exception; but let us not make the mistake of charging the fact to a blunder in the original formation of woman. To do so is to defeat the possibility of our attaining to anything better. When we are better educated this matter will surely be righted, and only then.

We profess to believe that education should include the whole man, physical, moral, and intellectual; but is not the attention given to physical education, as a rule, disproportionate to our professed belief in its importance? Culture of the intellect too often stands for the whole of education, and girls especially have grown to look upon matters pertaining to physical education as unworthy their attention.

Household esthetics.—The following were the general topics embraced in this study: General principles of taste as applied to ornamentation, requisites of furniture, wall and ceiling decoration, treatment of floors, selection of carpets, ceramic art, and the esthetics of dress. The university library furnished many valuable and rare works on household and decorative art for reference.

If, as Keats tells us, "A thing of beauty is a joy forever," then a study which seeks to secure more beauty in our homes, and so multiply joys, should take no mean place in the education of girls.

In the study of household esthetics one of the first points we endeavored to impress upon the girls was that women are not "instinctively authorities on all matters pertaining to taste" any more than upon metaphysical points, but that they may become such by much the same means as they would adopt to become proficient in metaphysics or literature, viz, by well directed study and effort. We referred them to art critics, who charge the decline in art largely to the false models kept so constantly before the eye, and so led them to appreciate the importance of having the objects by which we are surrounded in the home beautiful and in good taste. We taught them that a reform in woman's dress is demanded not only on the ground of health, but for well-defined esthetic reasons. In the art gallery we showed them the Venus of Milo in the majesty of her perfect womanhood, and noted her comparative chest and waist measure. We pointed to her as the model female form before which every true artist bows.

Through the influence of certain very helpful articles in some of our popular magazines, quite a general desire has been created to attain to something better than we have yet known in this direction in our homes. But by what means may girls acquire this knowledge? When one stops to think of it seriously, the marvel is not that women so generally offend in this respect, but rather that we should see even so much good taste displayed as we do, since it is only as a new departure in education that this subject constitutes any part of a course of study for girls.

In one term it is not possible to turn out finished art critics, but in this time, a teacher full of the spirit and importance of the subject can do much towards awakening thought and giving direction to future study.

Our manufactories will not supply us with artistic domestic articles till there is a demand for them by appreciative consumers. And this demand will not be made until our systems of education give the impulse.

The same amount of time that is now devoted by girls, irrespective of native aptitude, to dabbling in water-colors and oils, and to constructing cardboard air-castles, that have no real or apparent use, or, as Anna Brackett puts it, in "crocheting covers for covers, and covers for covers of covers," concentrated upon a vigorous, well-directed study of the principles of ornamentation, would do far more towards permanently beautifying our homes, walls, floors, chairs and tables, our daily lives, than we can ever know, so long as woman's leisure is given to those ephemeral productions that are so sadly out of place in a world where moth and dust doth corrupt, and where time is so valuable and opportunity so limited.

Under the name *household science* the following topics are treated: The principles of heating and ventilation, kinds and comparative values of different fuels, usual methods of heating dwellings, grates, stoves, furnaces, hot water and steam apparatus, culinary utensils, their most approved forms, properties of the materials of which they are made, iron, tin, copper, brass, &c., contaminations of food liable to occur from carelessness or from ignorance of the properties of certain metals, preservation of foods, chemistry of illumination. The adulteration of foods is treated by lectures and laboratory practice in testing foods.

Does it sound utopian to speak of the value to the housekeeper of skill in manipulating the microscope? Ah! but the utopian ideas of one age very often become the blessings of their successors, and the future may show that housekeepers who in their college days had the keenness of their sight multiplied from fifty to one thousand times in testing foods for adulterations and impurities, will consider a Zentmeyer's grand American microscope quite as indispensable to their households as a Chickering grand piano, a safe guarantee, aided by a knowledge of chemistry, that they will not give their children a stone when they ask for bread, or put poisoned confections in their darlings' stockings at Christmas time.

Domestic economy, as taught, included lectures on the conservation of the forces of the household, on expenditures, and on the management of servants. A series of lectures were given on the government and instruction of children.

If a knowledge of political economy be of service in the production and distribution of wealth, a knowledge of domestic economy is no less serviceable in securing a right use of that wealth. If a knowledge of the former is necessary for those who sit in parliaments and legislative halls, how much more necessary is a knowledge of the latter to those who rule over the homes and give to mind its first and most lasting impressions.

Plato taught us that the beginning is the chiefest part of every undertaking. We are very fond of saying "As the twig is bent the tree's inclined;" "She who rocks the cradle rules the world;" that what Napoleon needed to secure the welfare of France was "good mothers." Such expressions have long formed the key-note of addresses to young women, graduating from courses of study in which no instruction was given upon those all-important duties we all agree in declaring to be hers. If there be truth in these beautiful sayings why not act upon them in shaping courses of study for girls? Herbert Spencer pertinently asks, "Is it, then, that the unfolding of a human being in body and mind

is so comparatively simple a process that any one may superintend and regulate it with no preparation whatever? If not—if the process is with one exception more complex than any in nature, and the task of administering to it one of surpassing difficulty, is it not madness to make no provision for such a task? Better sacrifice accomplishments than omit this all-essential instruction."

Domestic economy well taught and intelligently practiced would save many a home from that worst of bankruptcies—the bankruptcy of peace, health, and happiness.

Etiquette.—The following topics were treated by lectures and discussions: Importance of a proper study of the rules of politeness and of the usages of good society; intimate relation of morals and manners; politeness but the embodiment of the golden rule; good manners not a thing to be put on with the Sunday dress, but to become a part of us by habitual use; etiquette of the home circle of the first importance; behavior in public places; visits, calls; hospitality a duty; dress, "cleanliness next to godliness;" forms of introduction; salutations; grace in personal bearing; the laws of conversation; sincerity in manner and speech cultivated; slang phrases, high-sounding adjectives, scandal, gossip, &c., to be avoided.

Home architecture.—We have no statistics to show the exact saving in time that would be secured to the world by having properly planned and constructed houses. But, doubtless, if the sum total of the time and energy lost to women in taking unnecessary steps in the course of the preparation of a meal from the inconvenience of absent or misplaced closets and doors that open the wrong way, from the vexation of spirit caused by smoky chimneys, the nervous and physical exhaustion due to stairs so constructed as to endanger life and limb, the impaired vitality, depression of spirits, days lost in sickness from rooms that cannot be properly ventilated and lighted could be presented to the social economist the showing would be something truly startling to him.

Women are the chief sufferers from these causes, but at present there seems no redress for them. He is a rare builder who is willing to concede that the average woman knows anything about how a house should be built. In very many cases we fear he is right. Many a woman has found when she attempted to direct these matters that she knew too little of architectural principles to be able to express her desires in an intelligible form. May we not in educating girls do something toward securing in the future houses for the people better adapted for homes? We believe so. In our school of domestic science the professor of architecture gave a series of lectures to the girls upon home architecture, including such topics as the principal architectural styles, general characteristics of exteriors, chief requisites of interiors, requirements of different apartments, sanitary requisites, cellars, walls, water supply, light, and convenience. To make the work as practical as possible the pupils were required to present drawings of original plans, and were taught how to make these drawings to a scale, and with a proper use of lines, shading, and colors.

The professor of horticulture taught them the general principles of landscape gardening, the kinds and uses of trees, shrubs, grass, and flowers, the construction and laying out of drives and walks, location of buildings, &c. The pupils first drew from copy, then, after the actual study of some locality with its environs, designed and drew full plans for its improvement. In the conservatory they had practice in the propagation and care of flowering and other ornamental plants. The young ladies took hold of this work with an enthusiasm which showed that they appreciated its value, and we believe that they will find in after life that the few weeks thus spent in their college days will bring them larger returns than if devoted to making copies of imaginary landscapes in oil and in manufacturing bouquets in water colors, or even in digging for Greek roots.

At the end of the course an original thesis was required on some subject bearing upon the technical studies of the school. The following are among the subjects selected by those who have graduated from this school: Art in the Home, Adulterations of Foods, Wheat, Chemistry of Foods.

Those who complete the full course receive the degree of B. S. in the college of natural science.

Such, in outline, was the technical part of the education given in this school of domestic science and the main principles on which it was based. Its results are yet to be told by the lives of its students; but enough has been seen to inspire the desire for the continuance of the experiment and for its extension in all the higher institutions of learning where women are educated. The sun of this nineteenth century, which has witnessed so much of progress in bringing the power of education to bear upon the work and well being of men, will not set till it has seen the school and college fling helpful light into the home and household—the work and well being of women.

The New York School of Cookery.

This school was founded in 1876 by Miss Juliet Corson. The first lessons were given in the ladies' course, where the instruction covered (1) the preparation of plain and in-

expensive articles of food in palatable and attractive forms; (2) the dressing of the remains of food in side-dishes suitable for breakfast and luncheon; (3) the elaborate and delicate dishes of artistic cookery.

In 1877 the plain cook's course was instituted for the purpose of teaching the principles of plain family cooking to young housekeepers in moderate circumstances, to young women employed as domestics, and to the wives and grown daughters of workingmen.

In 1878 the first and second artisan courses were planned for the instruction of the children of working people in cooking the cheapest kinds of food in simple and nutritious dishes.

The number of lessons given in the above-named courses from 1876 to 1881 was 740; the attendance, ranging through all social classes, was over 7,500 persons. In 1879 Miss Corson's illustrated lectures in the Cooper Union Saturday evening course were attended by about 5,000 people.

An important fact in connection with this instruction is that it has frequently been given in direct connection with young ladies' schools. In Montreal a special course of lessons was given to the pupils of the high school, under the supervision of the board of school commissioners, and many of the pupils of Mrs. Mercer's young ladies' school attended the lessons given before the Ladies' Educational Association.

Lessons were given in Farmington, Conn., before the pupils of Miss Porter's school. In Washington some of the lessons were attended by the scholars of Park and Mount Union Seminaries, Miss Ross' and Miss Osborne's schools, the pupils of the city normal and high schools, of the Spencer Business College, and the advanced grammar school.

During the year 1881 a class from Miss Brown's young ladies' school, of New York, has been regular in its attendance at the school of cookery. Two comprehensive lessons in cookery for the sick and convalescent were given in December, 1880, to the pupils of the training school for nurses attached to the New York Charity Hospital.

During the spring and early fall seasons Miss Corson gives lessons outside of New York, and has found large and interested audiences at Montreal, Canada; Washington, D. C.; Indianapolis, Ind.; Peoria, Ill.; Cedar Rapids, Iowa; Farmington, Conn.; Syracuse, N. Y.; Pittsfield, Mass., and Hartford, Conn.

Miss Juliet Corson also gives the following account of her work during the past two or three years:

During the season of 1880–'81 my local teaching comprised 144 lessons to twelve private classes of ladies, where the attendance numbered 120; 50 private lessons to individuals; 21 lessons to mixed classes, where the attendance reached the number of 150; 17 public lessons to cooks, attendance, 166; and 50 lessons to the children of working people, where the average attendance at each lesson was 8. One of the private classes was composed of quite young ladies, the pupils of Miss Annie Brown's school, No. 22 West 56th street, New York.

In December, 1880, I gave two lessons on the preparation of food for the sick and convalescent before the pupils of the Training School for Nurses attached to the Charity Hospital of New York. The class consisted of 30 nurses; the commissioners of charities and corrections and the resident and visiting physicians of the public institutions on Blackwell's Island were present.

The first lessons of the next season (1881–'82) given away from New York were at Pittsfield, Mass., for the Ladies' Art Association, and consisted of six lessons in general cookery to the ladies of the town and the pupils of Maplewood Institute for Young Ladies, the attendance being about 100, and six free lessons in economical cookery to working people, with an average attendance of 50.

The second course of outside lessons was given at Hartford, Conn., under the auspices of the City Mission, Mrs. Virginia T. Smith, superintendent; there were twelve lessons to ladies at Cheney Building, where the attendance numbered about 150, and twelve free lessons to working people at the Morgan Street Mission, to a class of about 50.

At the close of March, 1881, I resigned my connection with the charity department of the New York Cooking School, and continued my usual line of instruction as in previous years.

In April, 1881, I gave twenty-four lessons to ladies at Saint Louis, Mo., for the benefit of the Women's Christian Association of that city; the average attendance was about three hundred in the public class and fifty in a special private class. The president of the association, Mrs. C. R. Springer, in a letter dated May 29, 1881, says: "We cleared over $1,200. Have any people done better financially?"

From Saint Louis I went to Chicago, Ill., where I gave one lecture on Domestic Economy in Fairbank Hall, one free evening lesson to about five hundred working people, and eighteen public lessons to ladies.

In May, 1881, I gave six lessons to ladies, under the auspices of the Diet Dispensary of Cleveland, Ohio, to an audience of about one hundred.

In the same month, at Northampton, Mass., I gave seven lessons to a class of about one hundred and fifty ladies, one evening lesson to the students of Smith College, which was attended by President Seelye and the faculty of the college, and one evening lesson to working-people.

In June, 1881, I gave six lessons in cookery for invalids to the pupils of the New York State Training School for Nurses, in Brooklyn, Long Island, N. Y.

In September I went to Concord, Mass., at the invitation of Miss Ellen T. Emerson, and, under the management of that lady and Mrs. Judge Hoar, I gave six lessons to ladies, six lessons to cooks, and six free lessons to working people, in the old Concord school-house. These lessons were the inaugural series of the Concord Cooking School.

In December, 1881, I accepted the invitation of Captain R. H. Pratt, U. S. A., to visit the government Training School for Indian Youth, at Carlisle Barracks, Carlisle, Pa. At that time I gave a course of lessons to the Indian girls, some of whom did not speak or understand English, but all proved attentive and intelligent pupils.

The following extract from the paper published at the training school gives the local impression of the result of the lessons, and it is borne out by subsequent reports from the school, received from Captain Pratt during the past summer. A further indication of the genuine nature of the interest felt by the Indian girls is the pleasure they evinced when I promised to write an Indian cookery-book for them. They at once began to make lists of their cooking utensils and food supplies for my guidance. This book is now in hand. The following is the extract from The Big Morning Star:

"We were indeed glad to accept Miss Corson's generous offer to give our girls a course of lessons in cookery. Her teaching was simple and practical, and admirably adapted to the capacity of our Indian pupils. A table was placed ready for the lesson; in front of it were grouped the girls, and back of it stood Miss Corson, calling to her aid from time to time eager volunteers from the class. Beginning with the importance of absolute cleanliness the table was scoured, the utensils to be used were rubbed and polished until they shone. Only such materials and utensils were used as she learned from the girls they could get at their homes. Miss Corson's experience at the New York School of Cookery, where she has done so good a work in training poor children, enabled her to use such simple language, such telling gestures that even those with the least knowledge of English could follow and understand her teaching. Usually she had two or three dishes in course of preparation at once. A little girl washed potatoes, rubbing each carefully with a bit of rag, and deftly imitating Miss Corson, as she showed her how to pare a ring of skin from each, and then to boil them just long enough, so that they should be dry and mealy, slipping readily from their loosened jackets. Meantime another girl peeled more potatoes, and following her teacher's example neatly removed a thin, transparent paring, and cut out defects, and while she did it the whole class received a lesson in avoiding wastefulness. After each step in the lesson Miss Corson questioned the class as to what had been done and why it was done. In this way from plain and meagre materials very palatable dishes were prepared. It was a most interesting sight; the earnest watchfulness of the girls who looked on; the self-important little airs of the girls who carried out the lessons as they bent over the table and peered into the saucepans bubbling on the range. They made soups and stews; they baked and broiled; and even the much maligned frying-pan was brought into requisition, as Miss Corson taught them that it was possible to fry things without making them greasy and indigestible. As each dish was prepared she told them what other materials could be used in the same way. The pleasure of the girls in receiving this training was shown by their expressions in their home letters. * * * Miss Corson says she found the Indian girls as quick, and apt and enthusiastic as any pupils she has had. The desire to become good housekeepers became more eager from her pleasant teachings, and we are sure that when she comes again, as she has promised, she will find that they have not lost what they learned, and are ready to go on as far as she will take them."

The New York season of 1881–'82 was conducted as usual, instruction being given to both ladies and cooks, with the average attendance at the various lessons. During this season a course of twelve lessons to ladies and one free lesson to workingwomen was given at the Industrial Restaurant, No. 112 Lexington avenue, Brooklyn, N. Y. The class numbered about twenty.

In March, 1882, a course of six lessons in cookery for invalids was given before the physicians and nurses attached to the nurses' training school of the Brooklyn City Hospital, of which Mrs. Seth Low is president. The class numbered about fifteen.

In April a course of seven lessons to a private class of forty ladies was given in Stamford, Conn., under the management of Mrs. Schuyler Merritt.

It affords me great satisfaction to be able to make a favorable report of my connection with the Lake Erie Female Seminary, at Painesville, O. My first instruction there was given in the form of a course of six lectures on food and digestion, in the autumn of 1881, which were attended by about one hundred and forty of the pupils of the seminary

and many of the ladies of Painesville. These lectures were followed by a course of practical lessons in cookery in the autumn of 1882, attended by the entire school. The young ladies took an active part in the preparation of the various dishes, and the most excellent results are reported by Miss Mary Evans, principal of the seminary. These lessons in cookery form part of the regular course of instruction at the seminary.

The season of 1882–'83 in New York was begun in November, 1882, and is not yet finished. The usual instruction is being given to ladies and cooks, with the usual success. My labors among the working-people this season include the writing of a "Dietary for Workingmen," published in the workingmen's paper, the DAILY NEWS of New York; the revision of a paper on Domestic Economy for the Charity Organization Society of New York; the teaching of soup making to a woman chosen by Miss McBryde, of the Church of the Holy Trinity of this city; this soup is sold to the poorer members of the church and its missions at the cost of production. I am also giving a course of free lessons in economical cookery to these workingwomen at the same church.

In February of the present year I shall give a course of six lessons at Plainfield and at Morristown, N. J., assisted by Mrs. Thomas H. Taylor, who proposes to establish a cooking school at Plainfield.

In conclusion, I beg leave to call attention to a series of articles on "Dietetics," now appearing in Harper's Bazar; the subject is important, and has not yet been treated in an adequate manner. These articles will be republished in book form, probably during the present year.

JULIET CORSON,
Superintendent of the New York School of Cookery.

THE WORK OF MISS MARIA PARLOA AS A TEACHER OF COOKERY.

INDIVIDUAL WORK.

Each year the interest increases. I am constantly obliged to turn away applicants for admission to private classes. The public lectures were never better attended, but I am able to deliver only two a week; so much of my time is occupied in giving instruction outside of my own school. During the past year I have lectured thirteen times before the ladies of Springfield and three times before the working-women in the evening. At these lectures there were large audiences, and after I had completed my work in the city several cooking clubs were formed. At Lowell I gave nine lessons. Much interest was manifested, and a cooking school for working-women and children, with a few classes for ladies, is to be begun this month. A course of lectures on physiology, hygiene, and nursing was arranged for the working-women of Providence, R. I., and I gave three talks on cookery. These were largely attended, about 500 people being present at one on marketing. It is confidently hoped that a school will soon be established in Providence. A resident at Manchester-by-the-Sea employed me to give three lectures there this summer, and at the close of the series there was a call for more, but I had not the time for the lessons. I am now engaged to lecture at Taunton and expect to go also to Worcester. At Lasell Seminary, Auburndale, the work goes on prosperously. There is a course of twelve lessons during the school year, given by myself on alternate Saturdays, and there are practice classes, taught by the wife of the principal. Last year there was but one class, but there are now three. The girls take a deep interest in this study and demonstrate in their homes their ability to carry out the instruction received. During the present term is to be introduced, as a text book, "The First Principles of Household Management and Cookery, by Maria Parloa." Plans have been drawn for a model practice-kitchen. This is to be made as complete as possible, so that in one school at least have the most sensible preparations been made for the permanence of object lessons in cookery.

THE BOSTON COOKING SCHOOL,

which was started about three years ago by a special committee of ladies from the Woman's Educational Association (under whose auspices the Harvard examinations for women were inaugurated, and the Boston Art School and the women's department at the Massachusetts Institute of Technology were established—and they are now successfully carried on), is doing a broad work. Here there are classes taught by Mrs. D. A. Lincoln, whose time is fully occupied; classes of ladies and cooks, and of girls from the Horace Mann School for Deaf-Mutes. A normal department has been opened this year, in which I am the teacher. Already a number of pupils in this department have been assured of situations as teachers as soon as they are prepared to accept them.

The Boston Cooking School has established branches for poor women and children. In

1880 a demonstration lesson was given on one evening of every week, and several practice lessons were given during the week. This branch school is supported entirely by contributions. Last year about three thousand persons were present at the lessons, sometimes more than two hundred women attending at one time.

At the South End the second branch was started, and is supported by ladies of the South Congregational Society. Lessons are given in the vestry of the church. Though there is as yet only one lesson a week the interest grows steadily. These schools are doing great good among the poor.

OTHER MATTERS.

Miss Joanna Sweeney, who has given lessons in Boston six or seven years, has as many private classes as she is able to receive.

Madame Favier continues her private classes. At the rooms of the Young Women's Christian Association there are classes of school girls on Saturdays.

It thus appears that the interest here is not decreasing. On the contrary it is certain that there would be many more pupils if there were enough competent teachers.

MARIA PARLOA.

Information has recently been received from Miss Parloa of her work subsequent to that already described. It is as follows:

My last report to the Bureau of Educatton was made in the summer of 1881, when I was about to close my school in Boston, after a pleasant experience of four years in it, and seek a new field. In the fall I went West, and gave courses of six lectures or lessons at Chicago, Ill, twelve at Evanston, in the same State, and twelve at Milwaukee, Wis. The interest taken in my work was not so great as I had expected, although before the courses were finished it increased considerably. Returning in the spring to the East, and visiting New York, I gave a series of lessons under the auspices of the New York Cooking School. The audiences were large, and much interest was manifested. This work occupied Mondays and Tuesdays; on the other days of the week I lectured twice at West Winsted, Conn., and twice at Waterbury, and the patronage of both series was gratifying. In a month's time there were given ten lessons in New York, six in Winstead, and seven in Waterbury. At the end of these engagements a call to Buffalo, N. Y., took my attention. Ladies of that city had arranged two courses of lectures, one for the morning, for the benefit of themselves and their friends, and the other for the evening, for cooks. Plans also were made for three special evening lectures to working people. In the three weeks of my stay in Buffalo I gave thirty-three lessons. At all times the attendance was large, but it was particularly large at three free lectures, when it was necessary to turn hundreds of persons away, and at the lecture on marketing, which was so popular that it was repeated, by request, in a more spacious hall. At one lecture in Buffalo the audience numbered nine hundred. Much hope was expressed that a permanent school of cookery would be established, but I think it has not. From Buffalo I went, early in May, to Orange, N. J. Both there and at Newark I gave six lessons, two a week at each place. The other days of the week I spent at the Charity Hospital, Blackwell's Island, New York, giving instruction in sick-room cookery to the nurses and young physicians connected with the hospital and the training school for nurses. It was June before this labor was finished. In the early summer I prepared additional matter for my "First Principles of Household Management and Cookery" and then gave at Windsor, Vt., a course of lectures arranged by Miss Mary Evarts. At all lectures general information is given in regard to kitchen work and cookery and dishes are made in the presence of the audience.

During my stay in New York I became impressed by the vastness of the field, the great need of work and the desire for knowledge, and so, abandoning plans made for a European trip for purposes of study, I determined to establish a practice school in the metropolis of the country. I hoped to live to see cooking schools as practically and firmly founded in New York as in Boston. This I say not of any local pride, but because the work has received careful attention there for many years and has grown steadily on this account, so that it is now on a sure foundation, and appears likely to go on forever.

Having leased the house No. 222 East 17th St., New York, for a long term, I have had it so altered and furnished as to be commodious in every way for my purposes. Especially is it bright and inviting, so as to enhance the attractiveness of the work to be done. School was opened October 30, and every week there are given two public demonstration lessons. Thus far these have been well attended. There are several practice classes, in which the ladies do the work. Some of these I teach and some are taught by my assistant. The ladies who patronize the lectures and classes are of all ages, from the young girl to the white-haired matron, and a gratifying fact is that many report successful work at home. The nurses of the training school of the New York Hospital are soon to

begin taking a course of private lessons in cooking for the sick. I have lately given a series of lectures at Albany, N. Y., and two lessons at Orange, N. J., for the benefit of a hospital. This week I begin a course of twelve lessons at New Haven, Conn.

And so the work goes on. The school, as was the case in Boston, is entirely under my own management and maintenance. The expenses of the establishment are heavy enough to preclude my doing such charitable work as I would like to do and as is possible in those schools which are partly supported by subscriptions. The real need of the country, as I wrote you in 1879, is a national training school of cookery, where women and girls could receive a thorough education in physiology, chemistry, hygiene, and cookery. No private enterprise could give the same return as such a national school. When we have an institution of this kind, whose benefits are within reach of persons of small means, the work will go forward as it should.

REPORT ON COOKING SCHOOLS IN THE SOUTH.

WASHINGTON, *May* 9, 1881.

SIR: Cooking schools at the North have long since justified their existence, but that the South had room for them, or that it would even allow them foothold, had been doubted by all who imagine they knew southern characteristics and the inherited inaptitude for personal labor of any sort.

"A cooking school in the South! It can't be done;" insisted wise heads when the project was first unfolded. Prejudice will be too strong for you. Old conditions are powerful enough still to make personal labor a degradation, and you will not find a dozen people enlightened enough to care for or understand the virtue in such an undertaking."

SCHOOL AT RALEIGH.

In the mean time the said undertaking was progressing at Raleigh, N. C., with as much energy as was consistent with the modes of work prevalent there. The head of a flourishing school for girls located at that point—a man of unusual energy and in many points of advanced ideas upon education—had decided upon introducing the new branch, and a large and airy class room, fitted up in the best manner with every needed appliance for successful lessons, was organized. A few indorsed the movement, but for the most part it was regarded from the standpoint of the old Israelites—a standpoint as popular to-day as then—"all they that passed by did wag their heads for scorn." With the 1st of October, 1879, the course began, a class being formed from the very few in the city who had become interested, while two lessons weekly were given in the school itself. The names from this source had come in slowly, seven only expressing any willingness to "take," and even these hesitating and doubting if they were not in some mysterious manner to be betrayed into "niggers' work."

The first lesson settled this question. The class quadrupled and had to be limited as to numbers, and from October to May worked not only steadily but enthusiastically, accomplishing far more than had been expected for it. Utterly ignorant as most of them were in the beginning, and requiring to be taught details which come by intuition to the New England girl, within four months they were able to give a supper to the trustees of the school, not so elaborate in character as perfect in preparation, and at the end of the session each one was mistress of certain points which must inevitably redeem any home she enters from the curse of food ruined in the preparation. To make the best bread, brown and white, boil a potato perfectly, make coffee and tea as perfectly, and roast or broil or stew the rather dubious meat supply in the best and most savory way, may seem a small accomplishment, unless one knows something of what the southern dietary is, and has tested personally all the miseries involved in three meals daily of saleratus-biscuit or corn-pone, and bacon or beef fried to the consistency and flavor of old leather. Beginning with the southern antipathy to cold bread, the class quickly found that the amount prescribed for the lesson was by no means sufficient to meet the demand for it, and a keen rivalry began as to who should make the handsomest loaf. Household science generally made part of the course. Familiar talks and papers on all phases of this subject stimulated interest, and in addition a topic was given weekly—usually the history of some ingredient in the day's lesson. As the line of work came to be understood, inquiries came from various parts of the State as to its practicability and success. The classes for the towns-people had been well filled by enthusiastic learners, and in three months the "Raleigh cooking school" had no further need to question its future, but knew itself an assured success.

Some 45 lessons were given in the school girls' six months' course, a written examination ending it, and certificates of degrees of proficiency being given. Three courses of twelve

lessons each were given to ladies' classes from the city, and in March, 1880, a course was also given to a large class in Charlotte, N. C., and arrangements were made for organizing a school at Staunton, Va.

COOKERY FOR THE DEAF AND DUMB.

So recent is the interest in the questions of the education of the deaf and dumb, that to prove them susceptible of training at all has seemed a sufficient accomplishment. Each institution has had, in addition to the regular school course, its set of workshops, and the poorer boys, to whom some trade is a necessity, have learned basket and broom making, carpentering, &c., while the girls have been taught mattress making and sewing in general, as the only occupation open to them. For these girls, hedged in on every side, I would speak as in all senses more helpless, and appealing even more strongly than their brothers for training, and for some more potent weapon of defence in their journey through the world than the needle has ever proved.

Before giving details, there are several points to be considered, one or two of which are urged as objections to any general adoption of the new system.

Necessarily, institutions for the deaf and dumb must be filled with pupils from the lower, and often from the lowest, grades of society. Poverty, drunkenness, and disease own these unfortunates as offspring, and to many of them, gathered in from poorhouses and jails, or from homes where deepest want and degradation have ruled, the first knowledge of plentiful and wholesome food, of personal cleanliness, of kindness, or of any sense of brightness in life comes from their introduction to the asylum.

But, however clouded their intelligence, they prove, almost without exception, easily guided, keenly susceptible to sympathy, and reaching out with intense eagerness for any clew to the unknown life about them. No one who has worked among them can be insensible to the demand made by these shut-in souls, whose only avenue to understanding is the eye, and whose very presence is an appeal for all the light and help we may give.

So long as the asylum offers them a home, they are secure; but when the term of years in which the State provides for them has expired, what is the outlook? One or two, perhaps more, from each graduating class, are likely to become teachers; but the field is a limited one, and only very unusual intelligence admits of this possibility. A few others, from prosperous or comfortable homes, will return to be cared for by parents, till the chances and changes of life turn them over to the uncertain mercies of their nearest relatives. But the large majority are homeless, and must depend upon themselves. To such, only positions as seamstresses or nurses are open. For the latter field they are in many points unfit, while the former is already overcowded.

Work for women is in all cases hard to find and poorly paid. If this be so where full faculties go begging for it, how doubly is it so where communication must always be limited and hampered, and where training grudgingly given to the best fitted recipient would be withheld altogether from these, because demanding time and patience beyond the will of the employer.

Household service suggests itself as the only opening. But the instinctive prejudice against manual or rather menial labor which seems the American woman's instinct crops out as strongly in the deaf-mute as in the shop girl, who would rather stand fourteen hours daily behind a counter than one hour behind a cooking stove or wash tub. This prejudice, too deeply rooted at the North, is intensified at the South by every influence of inheritance and present surroundings. Until a new sense of the dignity of labor has reached the masses in the only way possible, that is through its indorsement by the better class, the work of overcoming such prejudice will be difficult and well-nigh impossible.

The perplexed philanthropist who has studied the limitations of his work dismisses the matter as settled when he has said, "Let them become cooks or housekeepers." He leaves the topic with the comfortable sense that "fiat cooks" is as potent a watchword as "fiat money" to the Greenbackers.

No popular delusion is more deeply rooted than the idea that all women take as instinctively to housekeeping as a duck to water. The bookkeeper, the merchant, the artisan admits the necessity of preliminary training, and submits to the inevitable apprenticeship with a patience born of the knowledge that only by and through training can any successful result be accomplished. But that the myriad details of housekeeping—the ordering of a home—the preparation or direction of the preparation of food, demand anything more than some instinctive sense is seldom admitted, such sense being supposed to come at the required time, whether previously developed or not. Women themselves are partially responsible for this theory, and announce that given a home any woman can oversee its details.

On this theory girls remain untaught, even where teaching would be easy. But it is always harder to do justly than to love mercy, and always more work is involved in teaching unskilled hands than in using one's own. And even where there is an honest

intention to teach days and months slip by. Any time will do, and "any time" ends in no time. If this is the case where teaching would be comparatively easy, how much more so where limited capacity and hopelessness of full communication and understanding still further complicate the work.

The home thus giving no surety of such training, and the homeless having even less possibility of the desired knowledge, the State must provide some means by which its wards may be saved from finally returning upon its hands as paupers. But the limitations of work already referred to have made the question a perplexing and baffling one to all who have sought its solution.

The solution must be found in opening up new and suitable avenues of employment, and of these, scientific and practical cookery offers one of the most useful and appropriate.

A year of quiet work in a class of ten, in the Institute for the Deaf and Dumb, at Raleigh, N. C., has shown what can be accomplished in a new industry, which, it has now been demonstrated, may form a part of the ordinary school training without interference with the usual course or any lengthening of the time required for its completion.

With the establishment and full success of the South Kensington Cooking School, followed shortly with equal success by those of New York and Boston, came the thought to one of the trustees of the North Carolina Institute for the Deaf and Dumb, that such schools might be a possibility for them. He was a man of broad culture and strong humanity, with whom thought and action marched hand in hand. No time was lost in suggesting the innovation, but in a conservative, slow-moving community, hampered by legislative stupidity, always more ready to work for future election than for public good, it was a long and tedious process. Aided at last by the warm coöperation of the principal, and stimulated by the fact that a cooking school had been projected and organized in connection with a large and liberally managed school for girls, known as Peace Institute, the necessary steps were at last taken. A room was fitted up with all essential appointments, and the superintendent of the Raleigh Cooking School, the first one in the entire South, was called upon for a course of lessons.

Beginning with many misgivings as to their success, yet with a faith that could not doubt their practicability for, at least, the most intelligent of the class, a month had not passed before suspense gave place to certainty. The class, the ten members of which were chosen from among the most intelligent pupils, was still of varying capacity. One or two were slow to understand, and awkward in execution. But the dullest face brightened as the lesson began. The least movement of the teacher was copied with Chinese minuteness. To a portion of the class, coming from homes where bacon and saleratus biscuit or corn-pone had been the chief diet, and where the range of cooking utensils are as limited as the food supply—not only the appointments of the room, but the articles to be cooked, were all mysteries. They were soon mastered, however. The quick eyes and ready hands speedily took possession of the new knowledge. A young teacher, chosen as interpreter, made all questionable points plain, and by her own careful preparation of her class-book gave a model, which all followed with greater or less success. Immediate objections were made by some of the parents, who looked upon the new departure as something designed to degrade their children, and who protested loudly that they should not do "niggers' work." But, as representatives of the best families had been chosen, this statement sufficed to quiet them, and the rapidly growing interest of the girls themselves completed the work.

Realizing that a portion of the system in use in the practice class of the cooking school proper must be set aside here, and that, with these limited intelligences, the physiology and chemistry of food could find little or no place, it became the superintendent's aim to form a set of lessons which should include chiefly simple and economical dishes perfectly prepared, and thus to lay a foundation on which each might build as circumstances might indicate. To this end breadmaking in all its forms, the best cooking of meats and ordinary vegetables and simple sweets, made up the greater part of the work. So unexpected were the results that within three months the class prepared the largest portion of a supper for the trustees, the delicate quality and serving of which were the best answer to any doubt that may still have lingered as to the efficacy of the new system.

With the close of the session in June, 1880, ten young girls left the institute with a well tested and established knowledge of principles in cookery, which will in time redeem whatever home they may enter from the curse of the inevitable ill-health and consequent ill-regulated thought entailed by the wretched cookery of the past. With her own hands each one had made, often enough to assure future certainty, bread, both white and brown; coffee and tea; had broiled a steak, and prepared meats in various ways—good soups and simple desserts—besides solving the mystery of cooking perfectly a boiled potato. Two or three of the class showed a special aptitude for the work, and having learned to their surprise that a lady could handle pots and pans, yet remain a lady, are

ready now for places from which a year ago they would have shrunk. Small as this entering wedge may seem its effects are incalculable. The cooking school means for the future of each pupil the largest result from the smallest expenditure; a knowledge which will make the cheapest and simplest food savory and palatable, and which, carried out, must end much of the chronic dyspepsia and general ill-health from which all suffer. Household labor dignified, its appliances made more perfect, and delicacy and order and daintiness ruling, in place of the dirt and wild confusion supposed to be the inseparable concomitants of all southern kitchens, a new race of servants will arise, and the generation of old family servants, fast passing away, and whose loss is daily mourned, will be replaced by a class to whom waste will be well-nigh impossible, and who will revolutionize old fashions, not by destruction but by reconstruction. Comfortable and adequate support need never fail the owner of this knowledge, and bondage to the needle will cease once for all. The session of 1880–'81 has had a building specially adapted to the purpose, the former one being slightly cramped, and a larger class were allowed the advantage of the course, an assistant trained last year having taken efficient charge of it.

The work is only in its infancy, but gives fullest promise of vigorous growth, and it is the superintendent's earnest wish and hope that it may not be confined to the Raleigh Institution, but may be attempted in others.

COOKING SCHOOLS AT STAUNTON, VA., AND WASHINGTON, D. C.

The school at Staunton, Va., opened the 1st of November, 1880, and continued to April 1, 1881, some forty lessons having been given to a class of about 30 school girls, and one course to a ladies' class. While retaining the general oversight of these schools, the headquarters of the superintendent will be hereafter in Washington, the Washington School of Cookery having been formally opened at 1323 H street, northwest, the workings of which will be on much the same plan as the Boston Cooking School, though modified by experience of special needs. A diet kitchen has also been organized in connection with the school, and Washington will, it is believed, admit of as representative work as has been accomplished in other cities.*

Beginning work in this field with the intention of using Miss Corson's system, it was very soon found impracticable. It demands the choicest supply our large city markets can afford, and the meat dishes have too characteristic a French flavor to be liked by those unaccustomed to French cooking. Miss Corson's admirable clearness of statement and dexterous handling can always be imitated to advantage, but practical work is better accomplished on Miss Parloa's theories. My own course based itself more and more on my experience as a housekeeper, both at South and North, and aimed at last simply to utilize to the best advantage the food supply of the place in which work must be done, with a constant effort to improve the nature of that supply, though the difficulties hedging about not only this but many other features of the work are more than it is worth while to consider here.

Finding, as before stated, no manual which met the need of classes, it became necessary to prepare one; and the publishers, Messrs. Fords, Howard & Hulburt, of New York, issued in February of the present year "The Easiest Way in Housekeeping and Cooking," adapted to domestic use or study in classes. In this I have aimed to cover the ground constantly talked over in all my class-work, and in small space to make a practical hand-book of household science. There are many most excellent authorities for the trained housekeeper, Marian Harland, Mrs. Henderson, Miss Parloa, and many others having made trustworthy and valuable books, but still not adapted to class use.

Interest is spreading so steadily that cooking schools must shortly be found in every city, North or South, where real progress is known, and the cooking school should and must include some knowledge of domestic science both in detail and as a whole.

HELEN CAMPBELL,
Superintendent of the Washington School of Cookery,
1323 *H Street, Northwest.*

Hon. JOHN EATON,
Commissioner of Education.

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*The cooking school in Washington is in a prosperous condition. It is composed of mission classes, a diet kitchen, and pay classes. The latter are for (1) cooks, (2) nurses, and (3) ladies. The mission classes are conducted by Miss Lizzie Gammill; the diet kitchen and pay classes by Mrs. R. A. Baker. Mrs. A. L. Woodbury has a supervision of the school, and makes it a place for the free instruction of the poor children of the city in this branch of household economy.

NEW CENTURY EVENING CLASSES FOR WOMEN.

The evening classes, conducted by members of the New Century Woman's Club of Philadelphia, include the following: Monday, German; Tuesday, cutting and fitting, sewing, physiology, elocution, French; Wednesday, arithmetic, literature; Thursday, cooking; Friday, book-keeping, writing, German, spelling; Saturday, French, grammar. The subjoined letter explains fully the origin and management of these classes:

PHILADELPHIA, *January* 29, 1883,
1112 *Girard Street.*

DEAR SIR: Your letter received in regard to New Century Evening Classes for Women in Philadelphia.

These classes were started last winter, as an experiment, by a few of the members of the New Century Woman's Club of Philadelphia. They are offered only to persons of limited means, whose day hours are occupied. The rooms of the club house are used for class-rooms, and the teaching is done mainly by club members. A few of the studies cost from 5 to 10 cents a lesson; but the rule is 50 cents for 24 lessons. The class of applicants ranges from house servants, laundresses, &c., up to teachers, a large proportion being saleswomen, clerks, cash-girls, &c. Last winter we had 226 pupils; this season, over 400; and the demand for such instruction being larger than we can supply, the pressure has resulted in the opening of several other such centers, working on precisely the same basis.

Several of the higher branches are not so superfluous as might at first appear, French, and especially German, being much in demand in stores. Embroidery is used in making articles for sale, drawing directly put to designs for embroidery, illuminating, &c.

The attendance after the first week or two, in which a few drop out and are seen no more, is remarkably steady, and we think it an encouraging fact that so many young women are willing, after a day of hard work, to devote the evening to mental improvement.

In connection with the classes, a course of Saturday lectures to women is in progress, chiefly on domestic subjects—"How to wash the baby," "How to cook for the sick," "What to do till the doctor comes," &c. We have also just started a society called "The New Century Women's Guild," with parlor, library, magazines, music, &c., to be always open to members at cost of $1 a year, as a place of recreation and also a center for whatever projects in the interests of women may grow out of it.

Yours, respectfully,

ELIZA S. TURNER.
Chairman Committee on Evening Classes in New Century Club.

Hon. JOHN EATON,
Commissioner of Education.

APPENDIX F.

INSTRUCTION IN CHEMISTRY IN INSTITUTIONS ENDOWED WITH THE NATIONAL LAND GRANT WHICH HAVE SPECIAL COURSES IN CHEMISTRY.

[Principally from Circular of Information No. 6, 1880.]

UNIVERSITY OF CALIFORNIA.

To students in the classical course lectures upon chemistry are delivered during the first half of the junior year. Students in the literary course take chemistry both in the lecture room and the laboratory throughout the sophomore year and may continue it as an elective in the first junior term.

In the several scientific departments a course of general and theoretical chemistry is given during the latter half of the freshman and the whole of the sophomore year. It embraces the elements of both inorganic and organic chemistry, and includes lectures, recitations, and laboratory work. The last is of an elementary character. In the college of mining, analytical chemistry, both qualitative and quantitative, is studied through the junior and senior years. In the college of agriculture the advanced lectures to the juniors are also given, together with a course upon organic chemistry in the senior year. Chemical analysis, with its special bearings upon agriculture, is carried through both the junior and the senior classes, and the juniors have also special instruction in agricultural chemistry. In the college of chemistry the entire four years' course of study leading to a degree is as follows:

Freshman year.—Algebra, solid geometry and conic sections, trigonometry, analytical geometry, rhetoric, composition, French or German, and elementary chemistry.

Sophomore year.—German or French, physics, inorganic and analytical chemistry, blowpipe analysis, general botany, industrial botany, and descriptive geometry.

Junior year.—History, zoölogy, political economy, surveying, physics, analytical chemistry, mineralogy, and theoretical chemistry.

Senior year.—Physiological, analytical, and organic chemistry, metallurgy, mineralogy, assaying, geology, physical laboratory, and thesis.

Students taking this course spend at least fifteen hours a week in the laboratory during the junior year and twenty hours a week during the senior year. Practical instruction in electrometallurgy is given to such students as desire it. Special students in chemistry are received.

The laboratories are open daily, including Saturdays. The room for quantitative analysis has accommodations for thirty-two students. Adjoining it are the laboratory and study of the professor, the balance room, and the fusion room. Below is a room for qualitative analysis, also with accommodations for thirty-two students. Adjacent to this is a room devoted to work in elementary chemistry. A charge of $15 a term is made for chemicals used in analysis. Breakage is also charged for.

YALE COLLEGE—SHEFFIELD SCIENTIFIC SCHOOL.

Chemistry in its different branches is the principal study of the chemical course. The other subjects, which in respect to the amount of time devoted to them may be termed the minor studies, besides contributing something toward a general scientific education, are for the most part connected with the main object of the course. A knowledge of French and German sufficient to render available the chemical literature of those languages is indispensable to the advanced student. Mineralogy is so intimately connected with chemistry that it may properly be termed the chemistry of natural inorganic compounds, while a knowledge of the more important elements or outlines of geology may be considered of sufficient value in itself to repay the student for the moderate amount of time required for its acquisition.

The freshman year, being designed to fit the student equally well for any of the courses which he may choose at the beginning of the junior year, must necessarily include some studies which are not absolutely indispensable as a foundation to his future course. The chemistry, physics, German, and in part the mathematics of this year may be regarded as strictly preparatory to the chemical course.

Junior year.—During a greater part of this year instruction is given by means of text-books and recitations in chemical philosophy or "theoretical chemistry." This may be considered as a continuation of the elementary chemistry studies during the freshman year. Throughout the year the student spends four consecutive hours in the chemical laboratory five days of every week. On one day of the week exercises in mineralogy take the place of chemistry. The laboratory study is devoted to a systematic course in analytical chemistry except during a part of the summer term, in which analytical chemistry is replaced by experimental work in organic chemistry. This work consists of the preparation by synthetic methods of a series of organic compounds, and is designed as a preparation for the systematic study of that branch of chemistry which is carried on during the senior year. French and German are studied throughout the year.

Senior year.—During this year also about four hours daily are given to the study of analytical chemistry in the laboratory. At the end of the first term the student is familiar with the most important general analytical methods. The subject of his laboratory work during the second term is to a great extent optional. He may, if desirous, gain experience in the assaying of ores or analysis of some particular class of products with a view to its technical application; or he may devote his time to original research on some subject of scientific interest. Not less important, although requiring less time, is the study of organic chemistry. On account of the lack of a suitably-organized laboratory for organic chemistry, experimental work which, under favorable circumstances, would be highly desirable, is not carried on in connection with this study during the senior year. Lectures in zoölogy are attended during the first term and recitations in geology during the year. These exercises, together with three lessons weekly in French, fully occupy the time not required for chemical studies.

Method of instruction.—In most of the studies of the course instruction is given by means of text-books and recitations in the usual manner, which requires no particular explanation. In regard to analytical chemistry, to which more time is allotted than to any other single branch of study in the course, it may be observed that it is intended to serve two purposes. It is to be used by the advanced student as a means of investigation in scientific or technical researches. The beginner, however, derives from its study advantages of another kind. The knowledge of the properties of chemical compounds and familiarity with chemical reaction gained by experience in the laboratory, and the development of the reasoning faculties by the application of this knowledge in analytical processes, enable the student to generalize and classify chemical phenomena and aid him to understand the more abstract theories of chemical philosophy. The method of instruction adopted is conformed to this view of the uses of the study. Text-books are used and recitations are required, but the more important part of both study and instruction is performed in the laboratory. In order to solve the problems which are thus presented, the student, aided by books and instructors, must learn both principles and their application.

Graduate work.—This school has been constantly increasing the facilities which it offers to graduate students for the study of different branches of chemistry. The laboratories for analytical and physiological chemistry are open seven hours daily for their use. They may begin with a course in quantitative analysis or with more advanced work, according to their previous preparation. Each one receives separately in the laboratory all assistance necessary to enable him to advance in proportion to his ability and diligence. Recitations in quantitative analysis accompany laboratory work during the first term of the year. Graduates may also, if desirous, attend any of the recitations or exercises belonging to the above described chemical course. After suitable preparation the undertaking of original investigations is encouraged. (The work of this kind carried on in our laboratories has afforded, it is believed, the most valuable training possible for the student and has often resulted also in the production of contributions to science of considerable value.)

Laboratories.—The chemical laboratories of the school may be designated according to their special uses as follows:

1. A laboratory for elementary chemistry, used exclusively for instruction of the freshman class.
2. A laboratory for qualitative analytical chemistry.
3. A laboratory for quantitative analytical chemistry and various chemical investigations.
4. A laboratory for physiological chemistry. An additional room in the basement of Sheffield Hall is fitted up with furnaces and apparatus necessary for assaying of ores in the dry way, while the practice required in determinative mineralogy is carried on in a laboratory arranged especially for this purpose in the Peabody museum.—(Sixteenth annual report.)

The special report on chemistry and physics, from which the statements of this appendix are generally taken, says: "Blowpipe analysis is taught in all the regular courses. In the engineering courses this study is taken by the seniors. Other courses have it in

the junior year. Students in the courses of 'natural history' and 'biology' have instruction in qualitative analysis during the first junior term. In the latter course toxicology and physiological chemistry are taught through the second junior term. Juniors in the agricultural course take the chemistry assigned for the same time to the chemical students. In the senior year they have agricultural chemistry."

University of Georgia.

There are two classes in chemistry, the junior and the senior. The students of the junior class study general chemistry, meeting the professor three times a week for ten months. Subjects are taken up in the following order: (1) The non-metallic elements; their history and their combinations with each other. (2) The principles of chemical nomenclature, symbols, and notation; the general principles of chemical philosophy. (3) The metals; their history, combinations, &c. (4) Organic chemistry. Text book, Fownes. This course is illustrated experimentally, and practical applications of the several subjects are duly noted. The senior class meet also three times a week for ten months, and study organic, industrial, and agricultural chemistry. Industrial chemistry is taught by lectures, illustrated by specimens, models, and drawings. The lectures upon agricultural chemistry begin about the 1st of March, and are free to the public, in accordance with the terms of the Terrell endowment. In this course the following subjects are presented: (1) The chemistry of the plant; (2) the anatomy and physiology of the plant; (3) the chemistry of the atmosphere; (4) the chemistry of the soil and its physical properties influencing agriculture; (5) means of improving the soil and influencing the growth of plants (farmyard manures, commercial fertilizers, &c.).

There is also a class for practical work in the laboratory. This class meets three times a week, spending on each occasion from two to four hours in actual practice. A thorough course of manipulation, blowpipe analysis, qualitative and quantitative analysis, is thus offered to students of the university.

The following course of study leads to the degree of bachelor of chemical science:

Freshman class.—English, algebra, geometry, drawing, history, botany.

Sophomore class.—English, algebra and geometry completed, history, book-keeping, geometrical drawing, elements of mechanics, trigonometry, mensuration and surveying (with practical exercises), botany, zoölogy, agriculture.

Junior class.—General chemistry; laboratory practice in manipulation, blowpipe analysis, and qualitative analysis; physics; English and English literature; French; German.

Senior class.—Industrial chemistry, including mining and metallurgy, chemical manufactures, &c.; agricultural chemistry; quantitative analysis, gravimetric and volumetric; physics; astronomy; French; German. The student is obliged to spend at least five hours a day in the laboratory six days of the week.

In the agricultural course the students are engaged in the laboratory six hours a week through the junior and senior years. Their work is necessarily in those portions of chemistry most directly related to agriculture.

The city of Athens contributed $25,000 for the erection of a laboratory building. This is a three story structure with a basement covering an area of one hundred by fifty feet. The entire first floor and basement are occupied by the department of chemistry, and contain analytical laboratories, balance rooms, an assay room, a room for microscopic and spectroscopic work, an industrial museum, store rooms, engine room, workshop, printing office, &c. The second floor contains a lecture room and museum for the department of agriculture, with an apparatus room, working room, and lecture room for the department of physics. The third floor is devoted to the department of engineering and drawing. The laboratories are open to students the whole of each day. A fee of $15 is charged to each student for the use of chemicals. A common set of ordinary apparatus is furnished at a cost not exceeding $10. Special students may, by permission of the faculty and payment of a fee of $35, take a course of chemistry alone, including lectures and laboratory practice.

The industrial collection of the university is quite extensive, numbering over four thousand items. It well illustrates the applications of chemistry to the useful arts and is made a prominent feature in the organization of the chemical department.

A few researches are reported upon such subjects as analysis of the cotton plant, of Georgia marls, tests of strength of Georgia timber and iron, and so on. The university was founded in 1800, and the sciences were taught from the beginning. In 1870 laboratory work was introduced, and it has since been made a part of the regular college curriculum. Chemistry and physics are not taught in the elementary schools of Athens.

Illinois Industrial University.

In the schools of agriculture and horticulture, chemistry is taught throughout the freshman year and agricultural chemistry during two sophomore terms. The latter is pur-

sued in connection with laboratory practice in the analysis of soils, fertilizers, foods, &c. The school of architecture has but one term of chemistry, with laboratory practice, in the junior year, while the schools of civil and mechanical engineering have double this amount. Students in mining engineering take chemistry, with laboratory practice, through two junior terms and the entire senior year. This laboratory practice covers qualitative and quantitative analysis, with assaying and blowpipe work, and is arranged with special reference to the needs of miners and metallurgists. In the school of natural history chemical instruction is given through the freshman year. In the two specially linguistic schools it is required for one junior term, but the school of English and modern languages offers an additional term as an elective. There is also a school of chemistry, in which a regular four years' course of instruction is provided. In this course text book recitations upon the principles of chemistry and chemical physics occupy six weeks of the first term. Through the remainder of the first year recitations alternate with laboratory practice. During the next three years each student is expected to work two hours daily in the laboratory, five days in the week. In order to graduate he must make an original investigation and present a thesis. Students who pursue chemistry incidentally to other courses work two consecutive hours daily in the laboratory during as many terms as their special "school" may require. The full course for a degree in the school of chemistry is as follows:

First year.—First term: Trigonometry, advanced geometry, British authors or French, chemistry with laboratory practice (the latter in qualitative analysis). Second term: Analytical geometry, American authors or French, chemistry, and qualitative analysis completed. Third term: Calculus or freehand drawing, rhetoric, French (optional), organic chemistry, and quantitative analysis.

Second year.—First term: Physiology or botany, German, quantitative analysis. Second term: Zoölogy or botany, German, volumetric analysis, alkalimetry and acidimetry, analysis of corn or other grain. Third term: Zoölogy, German, preparation of salts, acids, &c., electroplating.

Third year.—First term: Mineralogy, German, ultimate organic analysis, analysis of urine. Second term: Physics, German, blowpipe analysis and determination of minerals; assaying, both dry and humid, of gold, silver, and lead ores. Third term: Physics, German, photography, including the preparation of photographic chemicals.

Fourth year.—First term: Mental science, meteorology and physical geography, gas analysis, analysis of mineral waters. Second term: Constitutional history, logic, toxicology, including the microchemistry of poisons. Third term: Political economy, geology, original research, and thesis.

The purely chemical portions of this course are somewhat variable, in order to accommodate the needs of students who intend to become pharmacists, agriculturists, metallurgists, &c.

PURDUE UNIVERSITY.

Chemistry is required, with laboratory practice, two hours a day throughout the junior year. Inorganic chemistry occupies two-thirds of the time and organic chemistry one-third. No set text books are employed. The course includes theoretical chemistry, the elements of synthetical chemistry, qualitative analysis, and crystallography. Students use the balance and apply the principles of stoichiometry from the first. Definite quantities of substances are used, and the product of each reaction is weighed or measured, the actual quantities thereof being compared with the theoretical.

There are also two years of elective study, arranged as follows:

First year (second year from the beginning).—First term: Lectures on qualitative analysis, five hours a week; laboratory practice, ten hours a week. Second term: Lectures on qualitative analysis continued; soils, minerals, and fertilizers; principles of quantitative analysis; instruction five hours, laboratory work, ten hours a week. Third term: Quantitative analysis continued; general review of principles of analysis; time allotted as before.

Second year (third from the beginning).—Mineralogy, descriptive, mathematical, and determinative; metallurgy and assaying; organic chemistry, lectures, recitations, and laboratory work. Special reference is made to technical applications. Students taking this year's course are expected to spend from six to eight hours a day in actual laboratory practice.

MAINE STATE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS.

In this college there are five regular courses of study, as follows: (1) in agriculture, (2) in civil engineering, (3) in mechanical engineering, (4) in chemistry, and (5) in science and literature. Special students are also received.

Chemistry is required of all regular students through the sophomore year. The stu-

dents in agriculture continue the study during the junior year and the candidates for a chemical degree carry it on to the end of the course. In the first sophomore term there are daily recitations in general chemistry, based upon Roscoe's text book. These are supplemented by lectures. During the first junior term, the students in courses 1 and 4 recite daily together in agricultural chemistry. Through the second junior term and the whole senior year, the chemical students have daily recitations from Naquet's Principes de chimie, the latest French edition.

In courses 1 and 4 at least two hours daily through not less than nineteen weeks of the sophomore year are spent upon qualitative analysis in the laboratory. Quantitative analysis, at least two and a half hours daily, runs through the junior and senior years in course 4, but only through the junior year in course 1. The work done in quantitative analysis covers the usual ground of gravimetric and volumetric determinations, including assaying for gold and silver. Special attention is necessarily paid to agricultural analysis. Organic combustions and the more difficult analyses of complicated minerals, cast iron, and so on are undertaken by post graduate students. Four original researches in chemistry have been published from this college.

The laboratory facilities are good. The laboratory building contains two apparatus rooms, a lecture room, a cabinet, a library and weighing room, a recitation room, and rooms for analytical purposes. The general laboratory room measures 35 by 60 feet, is provided with gas and water, and accommodates thirty-two students. There is the usual supply of apparatus and chemicals.

Massachusetts Institute of Technology.

A certain amount of chemistry is required of all students who are candidates for degrees, namely, all the inorganic portion of Eliot and Storer's Elementary Manual, and, in qualitative analysis, a knowledge of general methods, with the ability to identify the various metallic elements in simple compounds and to prove the presence or absence of the commoner acids. Both general chemistry and qualitative analysis are taught by lectures and laboratory practice during the first school year. Students who pursue courses in chemistry, mining, metallurgy, physics, or natural history continue the study of qualitative analysis in their second year, the laboratory work being supplemented by lectures. In the second term of the same year they take up quantitative analysis. Chemical philosophy is taught to the students in chemistry and physics, partly by lectures and partly by recitations upon the basis of Cooke's text book. Strictly chemical students follow the preceding course with the study of organic chemistry, Schorlemmer's work being used as a basis for the lecture room exercises. Parallel with the latter there is a course of laboratory instruction, and some organic research is usually undertaken as thesis work. Other lines of investigation may, however, be chosen. Industrial chemistry is taught by lectures and laboratory practice, and instruction in physiological chemistry is also provided.

Candidates for a degree in chemistry have three courses of study open to them, all being identical in the first year. Course A runs as follows:

Second year.—First term: Qualitative analysis, analytical geometry, physics, English history and literature, German. Second term: Quantitative analysis, chemical philosophy, differential calculus, physics, English history and literature, German.

Third year.—First term: Quantitative analysis, microscopy, physical laboratory, constitutional history, German. Second term: Quantitative analysis, industrial chemistry, drawing, physical geography, dynamical geology, physical laboratory, political economy, German.

Fourth year.—First term: Organic chemistry, metallurgy, history of chemistry and allied sciences, abstracts of memoirs, applied physics, optional studies. Second term: Studies for this term, including thesis work, are specially assigned to each student.

In courses B and C mathematics is dropped at the close of the first year, being replaced by the natural sciences. Course B is for students who prefer a larger amount of the last named studies, and course C for those who intend to pursue industrial chemistry. The laboratories for qualitative and quantitative analysis were established in 1865. That for organic chemistry was started in 1877. The laboratory for industrial chemistry has been equipped during the past year, 1878–'79. No list of researches has been prepared, although a considerable amount of good work has issued from the institute.

Rutgers Scientific School.

In this school there are two regular courses of study, extending through four years, one in civil engineering and mechanics, the other in chemistry and agriculture. There is also a special course of two years in chemistry, with opportunity for post graduate work. Through the sophomore years, students in both of the regular courses attend

lectures upon theoretical and inorganic chemistry, using Barker's text book. The seniors in the engineering course also hear two terms of lectures upon organic chemistry and one term upon chemical physics. For the students in chemistry and agriculture, chemical instruction is given both in the junior and in the senior years. The juniors have determinative mineralogy and analytical chemistry, while the seniors continue their laboratory practice and hear lectures upon agricultural chemistry and chemical physics. According to the catalogue, the laboratory work of the last senior term seems to be devoted to a thesis. The special course of chemistry is as follows:

First year.—First term: Inorganic chemistry, stoichiometry, blowpipe and qualitative analysis, French, physics, thesis. Second term: Inorganic chemistry, qualitative analysis, physics, French, thesis. Third term: Inorganic chemistry, qualitative analysis, French, thesis.

Second year.—First term: Organic and applied chemistry, stoichiometry, quantitative analysis, physics, German, thesis. Second term: Organic and applied chemistry, quantitative analysis, physics, German, thesis. Third term: Geology, applied chemistry, mineralogy, German.

In all the lecture courses the students are required to take notes and to submit them to the inspection of the professor. Problems are given out for solution continually. In the laboratory a written report of every analysis is required. Rigid written and oral examinations are held at the end of every term. Original research on the part of advanced students is encouraged to the utmost. Post graduate students are taken in as subassistants and receive a certain compensation for their work; they thus acquire that most valuable discipline which teaching alone can give.

Cornell University.

The instruction in chemistry is substantially as follows: *General chemistry:* Sixty lectures inorganic and twenty-four organic, covering three terms of work. The organic chemistry is elementary. *Laboratory practice:* This begins with a course of exercises in elementary chemical manipulation. As little assistance as possible is given the student, to whom are left the result of each experiment and its interpretation. A written report of all work is daily handed to the instructor for criticism. After the usual qualitative course, quantitative analysis is taken up. Work is here laid out with reference to the future needs of individual students, whenever it is possible to do so. Those who are preparing for some application of chemistry to industrial processes are directed as early as possible towards original investigation in the line of the industry specified. Instruction in blowpipe analysis, determinative mineralogy, and assaying is given in the appropriate rooms at all laboratory hours. *Industrial chemistry:* Two series of sixteen lectures each occupy the third terms of two successive years. A collection of raw materials, waste, and finished products is being made to illustrate chemical industries and to exhibit before the class. The study of this material in detail is an essential feature of the course. Printed synopses of the lectures and copies of all diagrams used to illustrate them are given to each student who attends them. *Agricultural chemistry:* The course of instruction includes about sixty lectures and a large amount of laboratory practice. *Medical chemistry:* Students who intend to pursue the study of medicine receive a course of laboratory instruction in qualitative and quantitative analysis, the latter being especially in the line of the animal secretions. *Chemical philosophy:* Cooke's treatise is used as a text book, and special attention is paid to the problems contained in it. Lectures are also given upon recent developments of the subject, and the reading of Wurtz's History of Chemical Theory is required. *Higher organic chemistry:* Advanced instruction is given by lectures and recitations, the text book for the latter being either in French or in German. During the past year the second volume of Naquet's Principes de chimie has been used.

The laboratory rooms open to students are as follows: (1) the general laboratory for introductory and qualitative work; (2) a special laboratory for general quantitative analysis; (3) a special laboratory for agricultural and medical quantitative analysis; (4) a blowpipe room; (5) an assay room; (6) a room for spectroscopic and other optical work in chemistry; (7) a room for weighing and for the analysis of gases; and (8) a reading room. The last named room is well provided with chemical journals and works of reference.

All chemicals needed for experimental or analytical work are directly accessible to students. Gases are drawn from appropriate stop cocks in the general laboratory, at a table provided with pneumatic troughs. Hydrogen and sulphydric acid are carried to the different rooms of the laboratory from generators in charge of the curator. Richards's jet aspirator is used for water blast and filter pumps, one of the latter being attached to every working table in the quantitative laboratories. These rooms are also fitted with steam evaporating baths, drying closets, self regulating air baths at different temperatures, batteries for electrolytic determinations, and so forth. The laboratories are open

five days in the week from eight o'clock until five, and students are permitted to arrange their working hours according to their own convenience. But not less than two hours of continuous work can be taken at any time. Chemicals, apparatus, and gas are supplied to students at current prices.

A chemical and physical society has been organized by the special students in chemistry and physics for the reading of original papers and the general discussion of appropriate subjects. It meets semi-monthly in the laboratory building.

University of Vermont and State Agricultural College.

The classical students take chemistry in the second third of the sophomore year. The instruction is given by experimental lectures. A little laboratory work sometimes is taken as an extra. Students in the literary-scientific course may take chemistry in place of Greek. Engineering students receive three terms' instruction, lectures in the first freshman term and laboratory work in the second and third.

The agricultural and chemical students have chemistry throughout the course, except in the third term freshman and junior years. Even in these terms, however, a little chemical work may be done. The course of study is about as follows: Freshman year: First term, lectures on descriptive chemistry; second term, theoretical chemistry and laboratory work, the former being taught by recitations from Barker's text book and the latter consisting of exercises in manipulation and the preparation of chemical products; third term, blowpipe analysis. Sophomore year: First and second terms, qualitative analysis (Fresenius); third term, quantitative analysis. Junior year, first and second terms, quantitative analysis continued, both gravimetric and volumetric. In the second term, assaying and metallurgy are optional. Senior year: First term, recitations in organic chemistry and laboratory work. In the second and third terms, the agricultural students study agricultural chemistry. The chemical students do organic laboratory work in the second term, and during the third they take analytical, organic, or technical chemistry, according to option.

APPENDIX G.

INDIAN INDUSTRIAL SCHOOLS.

TRAINING SCHOOL FOR INDIAN YOUTH AT CARLISLE, PA.

UNITED STATES INDIAN SERVICE,
TRAINING SCHOOL FOR INDIAN YOUTH, CARLISLE BARRACKS,
Carlisle, Pa., January 22, 1883.

DEAR SIR: In compliance with your request I herewith furnish you a brief history of the Carlisle school and some account of its industrial features. In the spring of 1875 74 Indian prisoners were sent to Florida from the Indian Territory. At the instance of General Sheridan the War Department placed me in charge of those prisoners, they having been under my care at Fort Sill. They were from the Cheyenne, Arapahoe, Kiowa, and Comanche tribes, and were selected for this banishment because of well known offenses against the peace of the frontier. Some of them were guilty of the most outrageous crimes. Years of army service among the Indians and observation of their treatment had led me to favor giving to the Indian a broader chance, and to form a desire that he might be brought more in contact with the peaceful and industrious side of civilized life. Before the prisoners were started from Fort Sill, therefore, I wrote to my superiors urging that they be educated and trained industrially during their imprisonment. Soon after reaching Saint Augustine I wrote repeatedly to the War Department urging that some locality with more industrial surroundings be selected and the prisoners be transferred. This was denied, and I then set to work to make the best use of the elements to be found in the sleepy old Spanish town.

With no means I was forced to seek the coöperation of charitable and missionary folks. Miss S. A. Mather, Mrs. King Gibbs, Mrs. Couper Gibbs, of St. Augustine, and Mrs. Dr. Caruthers, of Tarrytown, N. Y., winter residents of St. Augustine, volunteered to teach and did teach the classes of those grown Indian men for two years and a half, giving them about an hour of instruction daily. Industrially, there was little practical opportunity, but numbers were placed at work for different periods in saw-mills, at picking oranges, as hostlers, grubbing the land, boating, and whatever could be found in connection with their own necessities and comfort in the old fort. Twice we boated pine logs from a distance and constructed log houses within the fort, riving the clap-boards, building stick chimneys, chinking and daubing, that they might learn to construct houses, to replace the skin tepes. Some of them advanced rapidly in acquiring literary, English speaking, and industrial knowledge. Others were very stupid. One of the most satisfactory results in the labor line was in placing five men to grub five acres that had intimidated other laborers, both white and black. The undergrowth and roots to be removed were of the most dense and appalling kind, and yet the Indians stuck to it until they had made a complete success of it, notwithstanding their blistered hands. A good evidence of the success of our labors was a petition to Congress, signed by a very considerable number of the laboring class and others of the community, asking that I be forbidden to put the Indians out to labor in competition with other classes, as I was taking bread from the mouths of those who were dependent upon such labor for their living, &c. In the spring of 1878 the authorities at Washington determined to release the prisoners and permit them to return to their homes. There were 22 of them who preferred to remain east and get a better knowledge of civilized life and more education before going home. The expenses of these 22 young men were assumed by charitable people. General S. C. Armstrong, of the Hampton Normal Institute, received 17 into his institution, and 4 went to Paris Hill, near Utica, N. Y., under the immediate charge of Rev. J. B. Wickes, an Episcopal clergyman, encouraged by Bishop Huntington, all the expenses being defrayed by Mrs. Burnham. One was taken to Tarrytown, N. Y., in Dr. Caruthers's own family. Hampton Institute is an industrial school, and furnished the most reasonable and practical education of any institution I was able to find. The remainder of the party were returned to their respective agencies, and such was the effect of their training in Florida during their three years' absence that they at once became the best element for progress in their tribes. At this time, while a few have gone

back to the blanket condition (most likely from necessity, because no other way was open to them), there is abundant testimony in the reports of their respective agents during the past four years that they continue to form a useful and leading industrious element among their people.

A few weeks after the arrival of the party at Hampton Institute General Armstrong was so favorably impressed with the conduct and progress of the 17 he had received that he was willing to accept 50 more, including girls. Mr. Schurz and Mr. McCrary, then Secretaries of the Interior and War Departments, accepted the proposition, and I was sent in the fall of 1878 to Dakota and brought away 49 children from six different agencies of the Sioux, Gros Ventres, Mandan, and Arickeree tribes. These, together with the former Florida prisoners, were placed under training in all the varied systems of literary and industrial pursuits Hampton Institute so liberally provides for its colored pupils. Side by side with those colored pupils the Indian boys and girls, in perfect harmony with the new life, demonstrated their capacity to hold their own in improving the best of chances. It was very much desired by the friends of this new move, and particularly General Armstrong, that I should remain with them, and a clause was introduced in the Army appropriation bill, which passed Congress in the spring of 1879, for the "detail of one officer not above the rank of captain for duty with reference to Indian education."

It was a theory I had advocated for several years, that to get the best results in our educational work among Indian children as many as possible should be removed from reservation and tribal influences and placed in an atmosphere of civilized life. To this end I had urged the use of vacant military posts and barracks as furnishing, without much cost in changing and improving buildings, places for making a beginning, and I now proposed to the Interior and War Departments to undertake the education of 250 to 300 children at the old military barracks at Carlisle. This proposition was accepted.

After many preliminaries I was sent in September, 1879, to the Rosebud and Pine Ridge Agencies in Dakota, whence I brought away 84 children, and immediately after went to the Indian Territory, and from the Kiowa, Cheyenne, Pawnee, and other tribes brought 52 more. To these were added 11 from the Hampton Institute of the young men who had been with me in Florida. The school was opened on the 1st of November, with 147 students. From time to time children from various western tribes came in, and at the end of July, 1880, we numbered 239 children, about one-third girls. At the end of the second year, October, 1881, we had increased to 295. At the present time we number 379, 132 girls and 247 boys. From the beginning our principle has been to place the most emphasis on industrial training, next English speaking, and then literary training. To accomplish the first we very early in the work established shops for mechanical instruction in carpentry, black-smithing, wagon-making, harness-making, tailoring, tin-smithing, shoemaking, printing and baking, and our farm of 115 acres gave some scope for agricultural training. We have avoided theory in our industrial training and adhered to practice, being governed to a great extent by the old apprentice system. We have at the head of each branch a skilled mechanic as practical instructor, and as nearly as possible we pursue the methods of trades-people in their instructions to apprentices. We give half of each day to work and the other half to school, and have found that our progress is proportionately greater in each than it would be if the attention was directed to either the one or the other for the whole time. Under this system we have under training as carpenters 13 boys; as wagon-makers and blacksmiths, 15; as harness-makers, 15; as shoemakers, 19; as tailors, 12; as tinners, 11; as printers, 5; as bakers, 3; and every boy not engaged at some trade is required to work during the season upon the farm. Such products of our labors as we are not able to make use of for the school are purchased by the Indian Department and shipped to agencies. We think our boys as forward in capacity for receiving instruction in each of the several branches as the average white boy. In the blacksmith shop our apprentice boys, after two years' instruction, are able to iron a wagon, repair a plow, shoe a horse, &c. In the wood-working department they are able to get out all the different wood parts of the wagon ready for the blacksmith; in the tinsmithing, to construct coffee-pots, buckets, pails, pans, cups, &c.; in the harness-making, to cut out and manufacture harness; in the tailoring, to cut out and manufacture clothing; in shoemaking, to repair and manufacture boots and shoes; in printing, to set up and distribute type and make up forms; in baking we have no other help than Indians. We give to our girls instruction in the various industries of the sex. In cooking, sewing, housework, laundry work, &c., they are apt pupils.

One of the most useful features of our work has been to place our boys and girls in private families, principally among farmers, where they perform the same kind of labor and are subjected to the same home and industrial influences as white children of their own age. This has led to the most beneficial results. The children take on English speaking and the industries of civilized life very speedily. During vacations we place out all we can spare from our own work, and during the winter we allow a considerable number to

remain and attend the public schools in the several neighborhoods, they being required to do such work mornings and evenings as they are capable of, and so pay for their board and clothes. By this course we are enabled to train a considerably larger number of pupils than we are allowed appropriation for. It is plain that the real hindrance to Indian progress is found in the fact that they are kept entirely separated from the other masses of our population, and by every act of our Government and every sentiment of its people, societies, missionary and other, made to feel that they are a separate people and must so remain forever. With their education in separate schools, with their home life on prison reservations, with their liberty of coming and going restricted to these reservations, with all their aspirations and ambitions so limited there can be no healthy growth. To overcome these difficulties the Indian mind and the mind of the public, as well as of Congress, must be educated to grant to them the enlarged privileges accorded to all other races. The boy will never learn to swim until he goes into the water, and the experiences of industrial and civilized life, through its associations and competitions, will determine for both Indian and white his true status. We have had quite enough of the Sioux, Cheyenne, Comanche, &c., as Sioux, Cheyenne, Comanche, &c. We can end their existence among us as such separate people by a broad and generous system of English education and labor training which will reach all the 50,000 children, and in a very few years remove all our trouble from them as a separate people and as separate tribes, and instead of feeding, clothing, and caring for them from year to year, put them in condition to feed, clothe, and care for themselves. Our experiences in many individual cases in the last few years make it very evident that not only may we fit the Indian to take care of himself in his own home, but may fit him to go and come and abide in the land wherever he may choose, and cease to be a savage.

We appreciate the difficulties of the return of our pupils to the great mass of uneducated and savage influence, but it must be borne in mind that the conditions of the Indians have entirely changed within the past decade. They are now hemmed in on all sides by the aggressive white population, their reservations are reduced to very small limits, and the passage of railroads through them, and the constant going and coming of white men, have so brought them in contact with civilized life that by those means and influences alone a great deal of pressure is brought to bear upon the tribes in general. So our returned pupils, instead of becoming isolated on their return to their people, become mediums of communication between their people and this surrounding civilization; and, whereas a few years ago an educated Indian returning to his people found himself entirely separated and useless as an educated and civilized man, he now finds himself a valuable medium for helping his own people to meet the overpowering wave of civilization that is upon them.

We have returned from Carlisle in round numbers about two hundred pupils since we began our work. I am safe in claiming that two-thirds to three-fourths of these returned pupils are exerting a most valuable influence on their tribes. Many of them are used by the agents in the schools and in the workshops and even in the offices of the agency. We have an instance where a young Sioux, after three years at Carlisle, has so fitted himself in his penmanship and knowledge of office duties as to get a salary of $60 a month as an assistant clerk. One of our graduates has charge of the discipline and management out of school hours of the boys in a school of 125 pupils. From the agent, from the teachers, and from the superintendent of the school I have the most flattering encomiums. Others are employed as blacksmiths, carpenters, harnessmakers, and shoemakers after having acquired some knowledge of these trades in our Carlisle school, and are standing examples to their people of the utility of civilized knowledge and occupations.

I would however revert to the original idea and that is the absorption of the Indians in our population the same as that of all other races that come from foreign shores to us. We must build forward and as rapidly as possible to the day when we shall have no exclusive schools for Indians, but when Indians shall enter into our school systems and into our labor systems the same as the other races; and it is not a very great matter to accomplish this result. We have upward of fifty millions of people, and we have only 261,000 Indians, one Indian to every two hundred of our population. There is not the same race prejudice against the Indian as against some other peoples. Indeed the whites may well be reminded that many now classed as Indians are more Anglo-Saxon than Indian. Besides, many traits of Indian character have always received the commendation of the Saxons.

The effect of our observation and experience in this work is to make us more and more confident of the successful result of well-directed industrial Indian education.

Very respectfully, your obedient servant,

R. H. PRATT,
First Lieutenant Tenth United States Cavalry, Superintendent.

Gen. JOHN EATON,
Commissioner of Education, Washington, D. C.

THE INDIAN SCHOOL AT FOREST GROVE, OREGON.

[From the Oregonian.]

The Indian Industrial and Training School at Forest Grove dates from the year 1879. In this year the appropriation of $5,000 was conditionally secured for the establishment of an Indian training school and Capt. M. C. Wilkinson, an energetic and enthusiastic advocate of this method of dealing with and settling. the Indian problem, was placed in charge of the work. This amount was by the Secretary of the Interior set apart for the purpose designated from the civilization fund created from the sale of Indian land in Kansas and was not a Congressional appropriation. Its conditions required the school to be in progress with an attendance of 25 pupils by the following July. Captain Wilkinson went immediately to work. A site was secured adjoining the town of Forest Grove on the northwest, consisting of four acres of land in a state of primeval wildness. Here ground was broken for the school in November, 1879, and the work was pushed forward with so much energy that on the 26th of February, 1880, the school opened with 18 pupils, gathered from the Puyallup tribe. With this first sum of $5,000 a clearing was made and a building 60 by 32 feet, two stories high, with a wing or addition 30 by 30 for kitchen, laundry, &c., was erected; the children were gathered from their homes, subsistence and stores were purchased, and employés paid for one year.

A nucleus was now formed around which industrial forces began to rally. In 1880 an appropriation of $10,000 was granted from the same fund, and another building of the same dimensions as the first was constructed by the labor of the Indian boys alone. Added to this building was a wood shed and wash room 24 by 15 feet. The four acre tract was cleared of trees and undergrowth, leveled, and inclosed with a substantial board fence, which, together with all buildings and outbuildings, was neatly whitewashed. Sidewalks were laid around the buildings and cross-walks between the two, these greatly aiding in keeping the floors clean. These buildings present on the outside an appearance precisely similar, and stand a distance of perhaps 200 feet apart. On the ground floor of the first are the school rooms, chapel, and boys' sitting room. The school rooms have comfortable seats and the same appliances in the way of maps, charts, blackboards, &c., that are usually found in the district school house. In the upper story of this building is the boys' dormitory, an apartment extending the entire length of the main building, passably well ventilated and kept scrupulously clean. The beds are placed in two rows, six feet apart, furnished with good mattresses and pillows and made comfortable by gray blankets. Two boys occupy each bed. The bedsteads are home made, or rather "school made," being the work of the boys themselves, under direction of Captain Wilkinson.

The second building contains on the ground floor the school dining room, the sewing room, and the matron's and superintendent's private apartments. On the upper floor is situated the girl's dormitory. This is divided into rooms, in each of which is a double bed, stand, &c., the older girls occupying the rooms in pairs. There is also an extension of this dormitory, arranged like that occupied by the boys, where the younger girls sleep.

The long tables in the dining room are neatly covered with white oil cloth, and when laid with linen washed and ironed by the Indian girls, and laden with well cooked vegetables, raised by the Indian boys, and surrounded by both girls and boys neatly clad and dining after the manner of civilized people, they present in themselves an encouraging picture of civilization.

As an individual instance of the great transformation effected in these heretofore untutored children of nature, the writer's attention was called to the Spokane girl who has charge of the table linen and general supervision of the dining room. It is stated that upon her arrival at the school some two and a half years ago she was a complete specimen of the wild, untidy Indian girl of the border, unable to speak a word of English, and was withal unusually repulsive in her appearance. So ready a pupil has she become in the ways of civilization that she is now as neat as any country lass; is careful and painstaking in the labor assigned her, speaks English quite intelligently, and is polite and engaging in her manners. Her case is but a single instance of the progress made by the girls in the art of civilized home making; and when these, after their term expires, are returned to their people the hope is certainly not without reason that their influence in cultured, womanly ways will be of vast benefit. The work and government of the house and school are thoroughly systematized and each department is placed under the charge of careful, competent, and thoroughly trained assistants, the whole being at present under the management of Mrs. Gertrude B. Wilkinson.

The employés are a clerk and superintendent, a matron, two teachers, a farmer, seamstress, blacksmith, shoemaker, and carpenter, who each supervise their special branch of industrial education. In conducting the school cleanliness and obedience are the first rules, and that these are carefully enforced is apparent to the visitor.

The sexes are kept strictly separate in play and work, the dividing line between the

two buildings and play grounds being indicated by a row of flower beds, being called by Captain Wilkinson the "dead line," but renamed by Mrs. Wilkinson the "life line," it being explained by this lady to the pupils, in her pleasant and convincing way, as the moral life of the Indian to observe strictly the social and moral conditions without which it is impossible for any people to be healthful, happy, and prosperous. Efforts are made to break up all tribal associations, those of race being deemed ample to hold the Indians in bonds of fraternal sympathy. Among the first things insisted upon is the use of the English language. So far as can be avoided, no "Indian talk" is allowed, and by strict attention to this matter the pupils are usually able, often in three or four months, to communicate tolerably well in English. Progress is made here to a certain extent, after which for a time advancement seems to cease altogether, until the pupil is taught to "think in English," thus making the language his own instead of a mere medium whereby his thoughts in the language of his tribe are conveyed. When this point is established the progress is more rapid, and is indeed in most cases quite satisfactory. In the schools the rudimentary elements of education are taught by oral and written methods and object lessons, each being patiently applied. As at present arranged each pupil spends a half day in the school room and a half day in the shops or work rooms. This rule is absolute, no pupil being excused except for illness. In industrial pursuits the boys are taught blacksmithing, shoemaking, carpentering, wagonmaking, and farming. The blacksmith and shoe shops are located in the center of the village of Forest Grove. There are in the first seven apprentices, and the cash received for their labor for the fiscal year ending June 30, 1882, was $1,038.50.

These boys are strong and muscular, work at the forge and wield the sledge with a will, and learn readily. In the shoemaker's shop are eight apprentices. These made shoes for the school from the 1st of March to the 31st of August, 1882, to the value of $212.25. The cash received for labor for the same period amounted to $133.95. In carpenter work during the two months preceding the last report made by Captain Wilkinson, thirteen boys built two dormitories 32 by 32 feet, 24 feet high; a sick ward, double walled, 25 by 36, 12 feet high; an addition to the kitchen, 14 by 28 feet, and in the same time made seven bedsteads. These boys did all the work, putting it together in a substantial and workmanlike manner, the carpenter of course directing. Last spring a tract of 45 acres of land was rented and 10 boys were put under the direction of the farmer. Of the tract 14 acres were pasture land, from which was harvested 10 tons of hay. On the residue was raised 5 bushels of onions, 300 dozen green onions for table use, 96 bushels of beans, 340 bushels of potatoes, 120 dozen cabbage, 150 bushels of apples, 6 bushels of plums, 10 bushels of pears, 56 bushels of peas, 153 bushels of beets, 154 bushels of turnips, 1,272 dozen ears of green corn and 10 bushels of tomatoes. The boys in addition to their work in the garden during the summer built a sewer 750 feet long and 4½ feet deep, cut 50 cords of wood for winter use and labored as opportunity offered in the neighboring harvest fields. It will be seen that the industrial progress of the boys is rapid and is of a varied character.

The girls on entering the school are first started at the wash-tub, the fitness of this being obvious, as personal cleanliness is unknown to them in a savage state. This is followed by instruction in ironing, dishwashing, preparing vegetables for cooking, sweeping, scrubbing, cookery, chamberwork, sewing, and mending. During the year ending June 30, 1882, they had, under direction of the seamstress, made 1,118 garments and had kept their own and the boys' clothes in repair, besides attending to their studies and taking their turn at housekeeping details. The most judicious care is exercised over the morals of all the pupils, their instruction in ways of modesty and virtue being not the least of the teacher's care. All pupils, unlesss ill, attend divine service every Sunday, and have on stated evenings prayer meetings and other religious exercises in their own chapel-room.

Their deportment during these services is usually good, as is also their deportment about the school, shops, and grounds. It is not claimed that Indian boarding schools are doing more than pioneer work. In their management there is neither precedent nor text-books to follow. From the first the school at Forest Grove has been hampered for means. The first three appropriations of $5,000, $10,000, and $15,000 from the civilization fund, as before stated, were supplemented last year by a Congressional appropriation of $30,000.

Want of funds has prevented the use of many conveniencies which are considered necessary to the proper management of a private family and which are even more essential to the smooth working of a large household. Too often the ingenuity of teachers is taxed to see how they could manage to do without instead of how they could teach the pupils to use the appliances of civilized life. The time heretofore allotted to the students for instruction in the training school was three years. It is apparent that to return immature youth to heathen homes after only three years' training in ways of civilization under specially favorable conditions is a hazardous experiment. Justice and true economy

alike require a supplemental course of at least two years to give the new habits formed time to take deeper root. Hence hereafter Indian parents will be expected to surrender their children for five instead of three years.

There are at present under instruction in the school 91 pupils, varying in age from 10 to 20 years. Of these 54 are boys and 37 girls. Twelve tribes are represented, as follows: Chehalis, 6; Alaskans, 12; Nesquallies, 3; Oyster Bay, 2; Pitt River, 2; Piute, 1; Puyallup, 22; Spokane, 18; Snohomish, 1; Umatilla, 10; Warm Springs, 2; Wascoes, 12. As has before been stated, efforts are made to abolish all tribal associations, and so successfully that one or two representatives of several tribes feel quite as much at home as those that are represented by large numbers.

The great need of the school at present is land. The four acres occupied belong to Pacific University, and efforts will be made the coming year to lease for a long term of years or to buy the site occupied. To earn the Congressional appropriation of $30,000 it will be necessary to have 147 pupils under tutelage for a year, and to accommodate the increased number the superintendent is now making important additions to the buildings. Captain Wilkinson, who had been in charge of the work from its inception, was a few months since ordered to join his regiment at Missoula and was thus compelled to relinquish the work. This removal is greatly to be regretted at the present stage of affairs, as it will be almost impossible for any one else to take up the work and carry it forward in detail without more or less loss of time. The Department of the Interior has, however, done the best possible thing under the circumstances, in placing Mrs. Wilkinson in charge. She has been from the first an enthusiastic worker, has shared fully all of her husband's plans, and has once visited Washington in the interest of the school.

It was thought best to separate the school proper entirely from Pacific University. This has accordingly been done and Lieutenant Pierce detailed to succeed Captain Wilkinson as professor of military tactics in the university. A visit to the Indian industrial school at Forest Grove will well repay the curious, the skeptic, or the humanitarian. The visitor who inspects it and learns from its workings cannot fail to be impressed favorably with the civilizing effects upon the Indian youth, and will look with interest as the years go on for a chronicle of the good results which can scarcely fail to follow this educational effort.

An account of Indian education at Hampton Institute, Virginia, has already been given in connection with the description of that institution in Appendix A.

INDEX.

The extended statements in the appendixes respecting individual institutions usually contain facts about (1) their objects; (2) finances; (3) faculties; (4) students; (5) scholarships; (6) courses of study; and (7) buildings and appliances. Entries under these headings were not generally made in indexing the appendices. Reference to the respective institutions will guide the reader to information on these subjects.

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47TH CONGRESS, 2d Session. } SENATE. { EX. DOC. No. 26.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING,

In response to Senate resolution of the 9th instant, a detailed statement of the cost of collecting the internal revenue in each collector's district of the United States.

DECEMBER 23, 1882.—Ordered to lie on the table and be printed.

TREASURY DEPARTMENT,
December 22, 1882.

SIR: In answer to Senate resolution of the 9th instant, I have the honor to transmit herewith a detailed statement showing the cost of collecting the internal revenue in each collection district in the United States, for the fiscal year ending June 30, 1882, the percentage of cost upon the total sum collected in each district, and the number of employés in each collection district; also a copy of a letter from the Acting Commissioner of Internal Revenue giving additional items of expense, which it is impracticable to distribute by districts.

Very respectfully,

CHAS. J. FOLGER,
Secretary.

Hon. DAVID DAVIS,
President of the Senate pro tempore.

Detailed statement showing the cost of collecting the internal revenue in each collection district in the United States for the fiscal year ended June 30, 1882, *and the percentage of cost upon the total sum collected in each district, and also the number of employés in each collection district.*

Districts.	Total collections.	Total expenses.	Per cent. of cost.	Number of employés.
First Alabama	$73, 504 25	$11, 670 62	.159	9
Second Alabama	67, 028 67	16, 973 27	.253	17
Arizona	45, 464 31	8, 027 80	.176	6
Arkansas	109, 039 36	23, 647 25	.216	20
First California	3, 814, 692 86	84, 179 86	.0222	65
Fourth California	312, 484 65	34, 527 96	.110	23
Colorado	247, 264 09	18, 091 18	.0731	14
First Connecticut	263, 811 83	19, 064 88	.0722	17
Second Connecticut	301, 989 45	15. 701 06	.0519	13
Dakota	67, 436 83	10, 311 44	.153	6
Delaware	350, 906 37	13, 552 70	.0386	10

Detailed statement showing the cost of collecting the internal revenue, &c.—Continued.

Districts.	Total collections.	Total expenses.	Per cent of cost.	Number of employés.
Florida	$280,227 32	$14,124 57	.0504	13
Second Georgia	264,054 21	60,577 38	.225	61
Third Georgia	95,306 66	23,653 06	.248	19
Idaho	31,908 27	8,088 17	.253	6
First Illinois	10,466,026 54	116,379 38	.0111	79
Second Illinois	261,351 75	10,021 48	.0383	7
Third Illinois	676,981 44	17,744 40	.0262	12
Fourth Illinois	1,247,764 75	30,648 21	.0245	33
Fifth Illinois	13,267,988 65	129,152 92	.0097	94
Seventh Illinois	75,595 53	5,444 34	.0720	4
Eighth Illinois	1,429,153 26	38,479 70	.0268	33
Thirteenth Illinois	827,555 45	24,725 66	.0299	19
First Indiana	253,745 94	14,892 89	.0587	15
Fourth Indiana	3,459,301 35	53,500 38	.0154	43
Sixth Indiana	1,164,648 03	21,664 92	.018	16
Seventh Indiana	1,306,664 77	25,765 82	.012	18
Tenth Indiana	196,885 66	10,177 39	.051	8
Eleventh Indiana	104,111 19	7,423 24	.071	6
Second Iowa	421,380 23	16,875 58	.040	15
Third Iowa	321,618 32	13,394 39	.041	9
Fourth Iowa	184,738 87	11,244 36	.060	10
Fifth Iowa	916,167 32	21,827 77	.023	21
Kansas	264,013 95	19,158 01	.072	14
Second Kentucky	955,021 75	99,996 10	.104	92
Fifth Kentucky	4,467,721 54	294,581 73	.065	231
Sixth Kentucky	3,435,658 55	111,988 88	.032	83
Seventh Kentucky	1,281,464 30	134,443 38	.104	111
Eighth Kentucky	221,709 36	42,924 62	.193	42
Ninth Kentucky	169,660 64	19,410 50	.114	17
Louisiana	918,899 19	41,044 63	.044	31
Maine	85,259 83	9,174 81	.107	7
Third Maryland	2,662,009 47	81,526 64	.030	61
Fourth Maryland	160,228 81	22,431 57	.139	21
Third Massachusetts	1,601,844 13	38,745 09	.024	28
Fifth Massachusetts	933,919 13	33,683 47	.036	26
Tenth Massachusetts	401,595 81	16,827 44	.041	13
First Michigan	1,362,945 87	18,280 24	.013	12
Third Michigan	273,718 46	9,539 39	.034	6
Fourth Michigan	164,576 96	7,506 80	.045	5
Sixth Michigan	201,949 76	9,271 07	.045	6
First Minnesota	125,071 40	9,392 16	.0751	9
Second Minnesota	403,420 54	14,597 60	.0362	10
Mississippi	94,098 90	20,861 10	.221	14
First Missouri	6,186,922 72	70,626 73	.0112	45
Second Missouri	65,405 90	12,536 27	.191	11
Fourth Missouri	498,833 39	15,219 29	.0305	11
Fifth Missouri	153,736 46	11,876 91	.0772	9
Sixth Missouri	634,589 47	34,907 33	.0550	26
Montana	68,001 31	9,370 27	.138	6
Nebraska	1,108,191 15	24,463 58	.0220	15
Nevada	49,103 93	8,076 09	.164	5
New Hampshire	349,942 04	11,539 81	.0333	7
First New Jersey	305,040 48	12,657 79	.015	10
Third New Jersey	459,988 40	18,367 49	.0399	17
Fifth New Jersey	4,686,604 72	27,651 59	.0059	20
New Mexico	55,903 38	8,251 91	.147	6
First New York	2,984,084 80	65,572 54	.0219	45
Second New York	4,206,252 54	64,278 00	.0152	42
Third New York	6,762,211 18	47,929 52	.0071	29
Eleventh New York	180,625 31	10,786 29	.059	9
Twelfth New York	627,261 92	15,474 67	.0247	14
Fourteenth New York	620,596 47	16,142 37	.0260	13
Fifteenth New York	346,397 30	9,889 87	.0285	7
Twenty-first New York	333,264 94	13,142 08	.0394	11
Twenty-fourth New York	469,857 05	14,862 37	.0316	10
Twenty-sixth New York	386,550 60	10,904 08	.0282	10
Twenty-eighth New York	1,134,541 13	22,997 99	.0203	17
Thirtieth New York	1,403,396 85	35,308 27	.0251	26
Second North Carolina	62,163 24	19,047 72	.306	19
Fourth North Carolina	1,022,309 00	41,529 13	.0406	36
Fifth North Carolina	1,274,767 96	59,690 47	.0468	79
Sixth North Carolina	508,174 32	159,970 36	.3147	235
First Ohio	11,928,253 84	164,751 28	.0138	114
Third Ohio	1,621,593 77	33,828 49	.0208	25
Fourth Ohio	475,943 53	15,737 58	.0330	11
Sixth Ohio	300,275 33	14,184 02	.0472	13

Detailed statement showing the cost of collecting the internal revenue, &c.—Continued.

Districts.	Total collections.	Total expenses.	Per cent. of cost.	Number of employés.
Seventh Ohio	$700. 260 02	$20, 253 58	.0289	15
Tenth Ohio	1, 021, 133 71	27, 825 93	.0272	25
Eleventh Ohio	1, 216, 251 21	22, 673 97	.0186	17
Fifteenth Ohio	201, 528 11	11, 959 83	.0593	9
Eighteenth Ohio	894, 059 79	29, 738 70	.0332	22
Oregon	88, 679 82	8, 743 39	.0986	5
First Pennsylvania	3, 011, 318 33	83, 959 34	.0278	59
Eighth Pennsylvania	689, 758 24	23, 610 51	.0342	21
Ninth Pennsylvania	1, 450, 720 01	32, 353 49	.0223	22
Twelfth Pennsylvania	423, 128 51	23, 305 33	.0550	22
Fourteenth Pennsylvania	242, 351 75	24, 372 78	.100	24
Sixteenth Pennsylvania	258, 917 37	29, 893 31	.115	28
Nineteenth Pennsylvania	144, 726 27	8, 136 41	.0562	6
Twentieth Pennsylvania	101, 605 53	11, 215 07	.1103	8
Twenty-second Pennsylvania	1, 685, 425 78	84, 513 93	.0501	64
Twenty-third Pennsylvania	767, 154 44	27, 319 30	.0356	20
Rhode Island	229, 258 48	10, 179 83	.0444	7
South Carolina	119, 099 79	42, 857 37	.368	34
Second Tennessee	118, 312 99	27, 706 44	.232	28
Fifth Tennessee	777, 590 72	99, 280 76	.127	86
Eighth Tennessee	101, 824 29	11, 977 93	.117	10
First Texas	87, 434 96	18, 271 18	.209	11
Third Texas	84, 372 68	15, 300 39	.169	10
Fourth Texas	86, 625 29	13, 602 57	.157	11
Utah	48, 523 08	7, 458 45	.154	5
Vermont	56, 444 58	6, 306 60	.111	5
Second Virginia	1, 010, 101 04	29, 705 92	.0294	26
Third Virginia	2, 144, 886 37	25, 178 75	.0112	23
Fourth Virginia	1, 096, 673 36	23, 121 05	.0211	21
Fifth Virginia	1, 740, 374 41	35, 324 92	.0203	31
Sixth Virginia	234, 273 12	42, 034 00	.179	39
Washington	40, 202 57	6, 657 53	.165	4
First West Virginia	366, 323 15	16, 076 79	.0436	15
Second West Virginia	135, 953 41	18, 007 06	.133	19
First Wisconsin	2, 560, 688 30	37, 247 83	.0146	24
Second Wisconsin	198, 570 39	9, 417 20	.0474	7
Third Wisconsin	258, 903 53	13, 183 93	.0509	11
Sixth Wisconsin	174, 953 00	8, 835 10	.0506	7
Wyoming	20, 385 65	5, 420 17	.265	3

TREASURY DEPARTMENT,
OFFICE OF INTERNAL REVENUE,
Washington, D. C., December 19, 1882.

SIR: I have the honor to return herewith the copy of Senate resolution of the 9th instant, referred to this office on the 12th instant, accompanied by the statement therein called for relative to the cost of collecting the internal revenue, &c.

This statement shows the total amount collected, the expenses of collection, the percentage of cost of collection upon the sum collected, and the number of persons actually employed in each collection district for the fiscal year ended June 30, 1882.

The expenses of collection are taken from the report of the Fifth Auditor of the Treasury for the last fiscal year, as shown on pages 35 to 38 of said report, deducting therefrom, in certain districts, the expenses belonging to a previous year, amounting to $30,816, as shown at the foot of the table referred to.

This statement does not include the following items, which it is impracticable to distribute by districts, viz:

Cost of dies, paper, and printing internal-revenue stamps	$565, 026 28
Salary of Commissioner and clerks employed in this office	253, 330 00
Miscellaneous expenses	32, 197 35
Salary and expenses of thirty-five revenue agents	122, 846 49
Expenditures for the discovery and punishment of fraud	52, 015 95

In this connection I would refer to the statement on page 19 of my report for the last fiscal year, showing how this last item was expended, and to page 11 of same report, showing the aggregate cost of collection of internal revenue, and the percentage of cost upon the entire amount collected.

Respectfully,

H. C. ROGERS,
Acting Commissioner.

Hon. CHAS. J. FOLGER,
Secretary of the Treasury.

[From report of the Fifth Auditor, pp. 35–38.]

Internal-revenue expenses for the fiscal year ended June 30, 1882.

District.	Expenses of collector's office.				Other expenses.		Total expense.	Expenses belonging to previous years.
	Salary of collector.	Deputies and clerks,	Rent, fuel, and light.	Stationery, expressage, and other expenses.	Compensation of storekeepers.	Compensation of gaugers.		
First Alabama	$2,500 00	$7,889 58	.....	$33 76	.....	$1,247 28	$11,670 62	.....
Second Alabama	2,500 00	11,557 15	$400 00	117 02	$2,030 00	369 10	16,973 27	.....
	5,000 00	19,446 73	400 00	150 78	2,030 00	1,616 38	28,643 89	.....
Arizona	2,250 00	4,375 00	650 00	227 81	.....	524 99	8,027 80	.....
Arkansas	2,875 00	12,789 33	165 66	303 76	6,732 00	781 50	23,647 25	.....
First California*	4,500 00	31,917 76	.....	939 69	21,897 00	25,524 41	84,778 86	$599 00
Fourth California*	3,125 00	17,689 55	915 00	129 20	5,136 00	7,677 21	34,671 96	144 00
	7,625 00	49,607 31	915 00	1,068 89	27,033 00	33,201 62	119,450 82	
Colorado	3,000 00	11,748 90	957 24	177 82	684 00	1,523 22	18,091 18	.....
First Connecticut	3,000 00	8,302 37	400 00	72 13	4,792 00	2,498 38	19,064 88	.....
Second Connecticut	3,125 00	8,631 38	409 80	146 85	936 00	2,452 03	15,701 06	.....
	6,125 00	16,933 75	809 80	218 98	5,728 00	4,950 41	34,765 94	.....
Dakota	2,750 00	7,098 65	325 00	137 79	.....	.....	10,311 44	.....
Delaware	3,250 00	8,200 00	320 00	98 02	.....	1,684 68	13,552 70	.....
Florida	3,125 00	10,261 54	580 50	121 03	.....	36 50	14,124 57	.....
Second Georgia*	4,000 06	26,020 05	99 52	530 92	25,184 00	5,489 83	61,324 38	747 00
Third Georgia	3,000 00	16,395 09	.....	332 11	1,664 00	2,261 86	23,653 06	.....
	7,000 06	42,415 14	99 52	863 03	26,848 00	7,751 69	84,977 44	

* Includes compensation of storekeepers for ten days in last fiscal year.

Internal-revenue expenses for the fiscal year ended June 30, 1882—Continued.

District.	Expenses of collector's office.				Other expenses.		Total expense.	Expenses belonging to previous years.
	Salary of collector.	Deputies and clerks.	Rent, fuel, and light.	Stationery, expressage, and other expenses.	Compensation of storekeepers.	Compensation of gaugers.		
Idaho	$2,125 00	$3,654 00	$359 50	$375 67	$1,252 00	$322 00	$8,088 17	.....
First Illinois	4,500 00	26,707 96	.....	746 97	35,892 00	48,532 45	116,379 38	.....
Second Illinois	3,000 00	4,773 30	394 27	104 71	1,252 00	495 20	10,021 48	.....
Third Illinois	3,875 00	5,923 47	574 30	70 63	4,676 00	2,625 00	17,744 40	.....
Fourth Illinois	4,500 00	12,337 93	551 57	390 11	6,682 00	6,186 60	30,648 21	.....
Fifth Illinois*	4,500 00	15,499 80	1,353 21	263 66	54,648 00	54,080 25	130,344 92	$1,192 00
Seventh Illinois	2,500 00	2,720 00	145 00	79 34	.....	.....	5,444 34	.....
Eighth Illinois*	4,500 00	10,700 00	.....	234 93	14,527 00	8,792 77	38,754 70	275 00
Thirteenth Illinois	4,125 00	14,096 57	.....	141 99	3,556 00	2,806 10	24,725 66	.....
	31,500 00	92,761 03	3,018 35	2,032 34	121,233 00	123,518 37	374,063 09	
First Indiana	3,000 00	6,798 60	.....	111 12	3,443 00	1,540 17	14,892 89	.....
Fourth Indiana	4,500 00	7,487 75	330 00	195 91	23,022 00	17,964 72	53,500 38	.....
Sixth Indiana	4,500 00	5,200 00	.....	115 48	7,095 00	4,754 44	21,664 92	.....
Seventh Indiana*	4,500 00	8,631 96	747 19	184 57	6,798 00	5,272 10	26,133 82	368 00
Tenth Indiana	2,750 00	6,243 50	167 65	57 05	.....	659 19	10,177 39	.....
Eleventh Indiana	2,625 00	4,065 57	116 30	77 12	539 25	.....	7,423 24	.....
	21,875 00	38,427 38	1,361 14	741 25	40,897 25	30,490 62	133,792 64	
Second Iowa*	3,375 00	5,200 00	331 25	153 03	5,052 00	2,952 30	17,063 58	188 00
Third Iowa	3,125 00	9,080 79	.....	226 54	.....	962 06	13,394 39	.....
Fourth Iowa	2,875 00	6,978 09	364 45	109 72	.....	917 10	11,244 36	.....
Fifth Iowa	4,250 00	7,548 03	.....	196 63	5,568 00	4,265 11	21,827 77	.....
	13,625 00	28,806 91	695 70	685 92	10,620 00	9,096 57	63,530 10	
Kansas	3,000 00	12,530 55	543 75	118 96	2,191 00	773 75	19,158 01	.....
Second Kentucky*	4,375 00	14,227 97	433 95	501 67	58,781 00	23,677 51	101,997 10	2,001 00
Fifth Kentucky*	4,500 00	23,660 44	87 50	554 82	200,600 00	70,558 97	299,960 73	5,379 00
Sixth Kentucky*	4,500 00	14,792 52	.....	226 71	57,493 00	36,461 65	113,473 88	1,485 00
Seventh Kentucky*	4,500 00	12,307 07	787 50	379 21	96,408 00	23,058 60	137,440 38	2,997 00
Eighth Kentucky	2,875 00	7,660 80	300 00	676 96	27,295 00	4,116 86	42,924 62	.....

Ninth Kentucky*	2,750 00	5,658 32	336 15	79 92	7,479 00	3,323 11	19,626 50	216 00
	23,500 00	78,307 12	1,945 10	2,419 29	448,056 00	161,196 70	715,424 21	
Louisiana	4,250 00	26,918 10	.....	274 09	2,196 00	7,406 44	41,044 63	.....
Maine	2,500 00	6,615 60	.....	59 21	.....	.....	9,174 81	.....
Third Maryland*	4,500 00	32,017 36	$475 00	237 73	16,900 00	27,936 55	82,066 64	540 00
Fourth Maryland*	2,750 00	6,234 59	250 00	104 30	12,823 00	593 68	22,755 57	324 00
	7,250 00	38,251 95	725 00	342 03	29,723 00	28,530 23	104,822 21	
*Third Massachusetts**	4,500 00	17,310 00	.....	134 90	6,000 00	10,960 19	38,905 09	160 00
*Fifth Massachusetts**	4,375 00	13,450 00	500 00	69 23	9,232 00	6,253 24	33,879 47	196 00
Tenth Massachusetts	3,375 00	8,200 00	461 94	183,01	2,504 00	2,103 49	16,827 44	.....
	12,250 00	38,960 00	961 94	387 14	17,736 00	19,316 92	89,612 00	
First Michigan	4,500 00	11,423 12	700 00	141 24	.....	1,515 88	18,280 24	.....
Third Michigan	3,000 00	6,278 46	200 00	60 93	.....	.....	9,539 39	.....
Fourth Michigan	2,750 00	4,064 40	.....	43 62	.....	648 78	7,506 80	.....
Sixth Michigan	2,875 00	5,900 00	314 60	181 47	.....	.....	9,271 07	.....
	13,125 00	27,665 98	1,214 60	427 26	.....	2,164 66	44,597 50	.....
First Minnesota	2,750 00	5,880 45	200 00	60 27	.....	501 44	9,392 16	.....
Second Minnesota	3,375 00	8,750 00	.....	149 96	.....	2,322 64	14,597 60	.....
	6,125 00	14,630 45	200 00	210 23	.....	2,824 08	23,989 76	.....
Mississippi	3,000 00	17,115 19	480 00	189 61	.....	76 30	20,861 10	.....
First Missouri*	4,500 00	23,467 91	2,192 35	795 15	13,228 00	26,819 31	71,002 73	376 00
Second Missouri	2,375 00	5,062 07	230 00	197 64	3,922 00	749 56	12,536 27	.....
Fourth Missouri	3,625 00	7,701 40	324 90	123 99	3,444 00	.....	15,219 29	.....
Fifth Missouri	2,750 00	6,580 25	320 00	135 40	1,842 00	249 26	11,876 91	.....
Sixth Missouri*	3,875 00	9,161 30	820 00	314 60	15,861 00	5,226 43	35,258 33	351 00
	17,125 00	51,972 93	3,887 25	1,566 78	38,297 00	33,044 57	145,893 53	
Montana	2,375 00	6,398 25	400 00	32 55	.....	164 47	9,370 27	.....
Nebraska	4,500 00	7,999 95	.....	68 55	6,538 00	5,553 08	24,659 58	196 00
Nevada	2,500 00	5,000 00	397 00	45 13	.....	133 96	8,076 09	.....
New Hampshire	3,156 25	5,746 27	.....	117 82	1,460 00	1,059 47	11,539 81	.....

*Includes compensation of storekeepers for ten days in last fiscal year.

Internal-revenue expenses for the fiscal year ended June 30, 1882—Continued.

District.	Expenses of collector's office.				Other expenses.		Total expense.	Expenses belonging to previous years.
	Salary of collector.	Deputies and clerks.	Rent, fuel, and light.	Stationery, express, postage, and other expenses.	Compensation of storekeepers.	Compensation of gaugers.		
First New Jersey	$3,125 00	$8,000 00	$150 00	$94 75	.....	$988 04	$12,657 79	.....
Third New Jersey	3,500 00	8,900 00	326 25	119 01	$2,504 00	3,018 23	18,367 49	.....
Fifth New Jersey	4,500 00	21,171 76	.....	214 57	.....	1,765 26	27,651 59	.....
	11,125 00	38,071 76	776 25	428 33	2,504 00	5,771 53	58,676 87	.....
New Mexico	2,500 00	4,805 63	700 00	102 88	.....	143 40	8,251 91	.....
First New York*	4,500 00	33,547 02	4,150 00	212 75	10,342 00	13,128 77	65,880 54	$308 00
Second New York	4,500 00	33,620 66	.....	516 90	.....	25,640 44	64,278 00	.....
Third New York	4,500 00	34,900 00	3,500 00	295 62	.....	4,733 90	47,929 52	.....
Eleventh New York	2,875 00	7,090 73	150 00	86 60	.....	583 96	10,786 29	.....
Twelfth New York	3,875 00	10,600 00	500 00	146 55	.....	353 12	15,474 67	.....
Fourteenth New York	3,750 00	8,759 99	634 25	110 44	.....	2,887 69	16,142 37	.....
Fifteenth New York	3,250 00	5,363 48	550 00	50 58	.....	675 81	9,889 87	.....
Twenty-first New York	3,250 00	6,675 36	723 39	167 68	1,152 00	1,173 65	13,142 08	.....
Twenty-fourth New York	3,499 92	6,602 83	817 79	230 14	1,280 00	2,431 69	14,862 37	.....
Twenty-sixth New York	3,375 00	6,499 54	341 25	87 44	.....	600 85	10,904 08	.....
Twenty-eighth New York	4,500 00	12,222 55	1,058 55	173 19	.....	5,043 70	22,997 99	.....
Thirtieth New York	4,500 00	14,470 50	.....	108 57	7,252 00	8,977 20	35,308 27	.....
	46,374 92	180,352 58	12,425 23	2,186 46	20,026 00	66,230 78	327,596 97	
Second North Carolina†	2,625 00	12,684 92	230 00	108 15	2,578 00	821 65	19,047 72	.....
Fourth North Carolina	4,500 00	27,527 15	.....	310 21	6,524 00	2,666 77	41,529 13	.....
Fifth North Carolina*	4,500 00	19,250 00	600 00	452 20	35,553 00	1,504 27	61,859 47	2,169 00
Sixth North Carolina*	3,625 00	33,190 51	310 00	904 35	115,567 00	10,897 50	164,494 36	4,524 00
	15,250 00	92,652 58	1,140 00	1,774 91	160,222 00	15,891 19	286,930 68	
First Ohio*	4,500 00	25,843 53	2,359 56	408 97	47,628 00	85,251 22	165,991 28	1,240 00
Third Ohio	4,500 00	11,275 25	1,097 00	153 07	9,472 00	7,331 17	33,828 49	.....
Fourth Ohio	3,625 00	5,535 88	198 37	101 63	3,756 00	2,520 70	15,737 58	.....
Sixth Ohio	3,125 00	4,300 70	172 12	70 14	4,056 00	2,460 06	14,184 02	.....
Seventh Ohio*	4,000 00	8,047 10	861 05	123 27	4,508 00	2,840 16	20,379 58	126 00
Tenth Ohio*	4,500 00	11,000 40	739 11	171 57	6,832 00	5,269 85	28,032 93	207 00

Eleventh Ohio	4,500 00	7,509 50	319 68	127 62	4,618 00	5,599 17	22,673 97	----------
Fifteenth Ohio	2,875 00	5,690 40	144 41	58 38	3,085 00	106 64	11,959 83	----------
Eighteenth Ohio*	4,250 00	15,877 47	843 88	151 97	5,832 00	2,981 38	29,936 70	198 00
	35,875 00	95,080 23	6,735 18	1,366 62	89,787 00	114,260 35	343,204 38	
Oregon	2,500 00	5,065 35	----------	65 46	----------	1,112 58	8,743 39	----------
First Pennsylvania*	4,500 00	37,925 98	----------	293 55	4,752 00	36,595 81	84,067 34	108 00
Eighth Pennsylvania*	3,875 00	11,384 35	650 00	134 62	5,118 00	2,574 54	23,736 51	126 00
Ninth Pennsylvania	4,500 00	14,204 13	749 95	183 37	11,002 00	1,714 04	32,353 49	----------
Twelfth Pennsylvania	3,375 00	13,541 14	562 00	275 02	2,718 00	2,834 17	23,305 33	----------
Fourteenth Pennsylvania*	3,000 00	7,217 77	211 25	98 97	13,634 00	624 79	24,786 78	414 00
Sixteenth Pennsylvania	3,000 00	8,071 07	264 71	101 90	18,221 00	234 63	29,893 31	----------
Nineteenth Pennsylvania	2,750 00	4,854 70	----------	74 57	----------	457 14	8,136 41	----------
Twentieth Pennsylvania	2,625 00	4,972 29	117 80	56 98	3,443 00	----------	11,215 07	----------
Twenty-second Pennsylvania	4,500 00	17,993 56	1,184 00	543 24	42,637 00	17,656 13	84,513 93	----------
Twenty-third Pennsylvania	4,000 00	10,035 42	405 75	45 52	6,777 00	6,055 61	27,319 30	----------
	36,125 00	130,200 41	4,145 46	1,807 74	108,302 00	68,746 86	349,327 47	
Rhode Island	3,000 00	6,400 00	----------	61 59	----------	718 24	10,179 83	----------
South Carolina*	3,375 00	28,133 76	----------	261 28	10,299 00	1,115 33	43,184 37	327 00
Second Tennessee	2,625 00	11,557 45	----------	265 48	10,947 00	2,311 51	27,706 44	----------
Fifth Tennessee*	4,125 00	21,274 15	561 95	649 94	65,351 00	9,449 72	101,411 76	2,131 00
Eighth Tennessee	2,625 00	7,103 89	361 00	60 39	1,763 00	64 65	11,977 93	----------
	9,375 00	39,935 49	922 95	975 81	78,061 00	11,825 88	141,096 13	
First Texas	3,000 00	12,379 55	819 20	189 93	----------	1,882 50	18,271 18	----------
Third Texas	2,500 00	9,430 09	338 80	300 11	2,504 00	227 39	15,300 39	----------
Fourth Texas	2,456 85	9,399 75	375 00	132 30	1,209 00	29 67	13,602 57	----------
	7,956 85	31,209 39	1,533 00	622 34	3,713 00	2,139 56	47,174 14	----------
Utah	2,500 00	3,400 00	408 00	17 35	----------	1,133 10	7,458 45	----------
Vermont	2,375 00	3,625 84	198 40	63 61	----------	43 75	6,306 60	----------
Second Virginia	4,500 00	19,925 24	----------	529 24	----------	4,751 44	29,705 92	----------
Third Virginia	4,500 00	17,100 00	----------	140 37	90 00	3,348 38	25,178 75	----------
Fourth Virginia	4,500 00	15,984 42	659 59	147 89	----------	1,829 15	23,121 05	----------
Fifth Virginia*	4,500 00	22,848 08	1,100 00	194 79	2,903 00	3,855 05	35,400 92	76 00
Sixth Virginia*	3,000 00	11,600 00	339 80	158 30	23,702 50	3,962 40	42,763 00	729 00
	21,000 00	87,457 74	2,099 39	1,170 59	26,695 50	17,746 42	156,169 64	

†Includes $125, salary of previous year.
*Includes compensation of storekeepers for ten days of last fiscal year.

Internal-revenue expenses for the fiscal year ended June 30, 1882—Continued.

District.	Expenses of collector's office.				Other expenses.		Total expense.	Expenses belonging to previous years.
	Salary of collector.	Deputies and clerks.	Rent, fuel, and light.	Stationery, expressage, and other expenses.	Compensation of storekeepers.	Compensation of gaugers.		
Washington	$2,250 00	$3,927 36	$250 00	$230 17	.....	.....	$6,657 53	.....
First West Virginia	3,250 00	10,193 50	200 00	135 12	.....	$2,298 17	16.076 79	.....
Second West Virginia*	2,750 00	6,060 62	231 00	256 51	$5,175 00	3,740 93	18,214 06	$207 00
	6,000 00	16,254 12	431 00	391 63	5,175 00	6,039 10	34,290 85	
First Wisconsin*	4,500 00	10,880 96	.....	226 47	11,244 00	10,588 40	37,439 83	192 00
Second Wisconsin	2,875 00	5,512 20	.....	93 56	.....	906 44	9,417 20	.....
Third Wisconsin	3,000 00	8,277 69	500 00	92 53	654 00	659 71	13,183 93	.....
Sixth Wisconsin	2,750 00	5,645 65	280 14	159 31	.....	.....	8,835 10	.....
	13,125 00	30,346 50	780 14	571 87	11,898 00	12,154 55	68,876 06	
Wyoming	2,125 00	2,870 50	350 00	74 67	.....	.....	5,420 17	.....
								30,816 00

*Includes compensation of storekeepers for twenty days of last fiscal year.

Amount expended through collectors of internal revenue in the employment of persons for the detection of frauds, and for information leading to the discovery of frauds, and punishment of guilty persons.

Name.	District.	Amount.
Brayton, E. M	South Carolina	$1,366 00
Blaine, John E	Ninth Kentucky	178 00
Clark, Andrew	Second Georgia	2,636 00
Cooper, H. M	Arkansas	45 00
Duval, I. H	First West Virginia	44 00
Everitt, G. B	Fifth North Carolina	151 86
Eagan, Dennis	Florida	295 91
Harvey, J. D	First Illinois	38 96
Hartson, C	First California	15 00
Johnson, W. H	Second Georgia	104 00
Landram, W. J	Eighth Kentucky	1,189 00
Mott, J. J	Sixth North Carolina	408 00
Melton, J. M	Second Tennessee	151 00
Patterson, R. F	Eighth Tennessee	263 30
Pollock, W. J	First Pennsylvania	251 00
Rives, J. H	Fifth Virginia	549 50
Rapier, J. T	Second Alabama	471 50
Stuart, W. A	Second Kentucky	53 00
Simpson, J. E	Third Iowa	50 00
Wilson, W. S	Fifth Kentucky	258 20
Woodcock, W. M	Fifth Tennessee	1,404 55
Wade, E. C	Third Georgia	285 00
Young, I. J	Fourth North Carolina	263 00
Total disbursed by collectors		10,471 78

Amount expended for like purpose through revenue agents

Name.	Amount.
Brooks, A. H	$7,724 60
Blocker, O. H	609 63
Chapman, W. H	1,208 88
Crane, A. M	168 50
Creager, M. H	352 20
Dowling, P. H	1,475 22
Eldridge, C. W	389 63
Grimeson, T. J	1,121 50
Hale, J. H	104 00
Kinney, T. J	1,186 94
Kellogg, H	800 95
Meyer, F	1,645 80
McCoy, J. B	5 50
Packard, J	2,318 44
Raum, J. M	1,441 54
Somerville, William	4,175 48
Spaulding, D. D	1 50
Tracie, T. C	683 75
Thrasher, L. A	2,122 61
Trumbull, J. L	178 20
Webster, E. D	1,324 98
Wilson, G. W	721 55
Wheeler, J. C	56 00
Wagner, J	237 25
Total disbursed by revenue agents	30,054 65

Amount expended by collectors	$10,471 78
Amount expended by revenue agents	30,054 65
Rewards under circular No. 99	5,103 27
Rewards under circular of March 10, 1875	806 25
Miscellaneous	5,580 00
Total	52,015 95

COST OF COLLECTION.

The cost of collection for the past fiscal year, distributed among the different items of appropriation, was approximately as follows:

For salaries and expenses of collectors, including pay of deputy collectors, clerks, &c	$1,980,790 88
For salaries and expenses of revenue agents, surveyors of distilleries, gaugers, storekeepers, and miscellaneous expenses	*2,256,318 37
For stamps, paper, and dies	565,026 28
For expenses of detecting and punishing violations of internal-revenue laws	52,015 95
For salaries of officers, clerks, and employés in the office of Commissioner of Internal Revenue	253,330 00
Total	5,107,481 48

The total expenses (including the expenses of this office) will be found, on final adjustment, to be less than 3½ per cent. on the amount collected. The expenses of collection for the last six years have been about $27,087,300, or about 3.6 per cent. on the amount collected. This sum has been disbursed without loss to the government.

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* This item is liable to be slightly increased by the payment of a few accounts not yet adjusted.

47TH CONGRESS, 2d Session. } SENATE. { EX. DOC. No. 27.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING

A letter from the Secretary of the Interior, inclosing a communication from the secretary of the Territory of New Mexico giving reasons why an appropriation should be made for the completion of the capitol at Santa Fé.

DECEMBER 27, 1882.—Read and referred to the Committee on Territories and ordered to be printed.

To the Senate and House of Representatives:

I submit herewith a letter from the Secretary of the Interior, inclosing a communication from the secretary of the Territory of New Mexico, who is custodian of the public buildings at Santa Fé, in which are set forth reasons why an appropriation should be made for the completion of the capitol at Santa Fé, and commend the matter to the attention of Congress.

CHESTER A. ARTHUR.

EXECUTIVE MANSION,
December 27, 1882.

DEPARTMENT OF THE INTERIOR,
Washington, December 22, 1882.

SIR: I have the honor to state that prior to the year 1860 the sum of $77,000 was expended by the United States upon a building at Santa Fé, N. Mex., intended for the accommodation of the Territorial legislature, the United States court, and for other purposes connected with the government of the Territory. I inclose herewith a copy of a letter from the secretary of the Territory, who is by law custodian of the public buildings at Santa Fé, in which he sets forth certain considerations why the building should be completed, and gives an estimate of the amount necessary to complete it. I respectfully suggest that the matter be submitted to Congress.

Very respectfully,

H. M. TELLER,
Secretary.

The PRESIDENT.

SECRETARY'S OFFICE, TERRITORY OF NEW MEXICO,
Santa Fé, N. Mex., December 11, 1882.

SIR: I have the honor to hand you herewith informal specifications and estimate for the completion of the old state-house at Santa Fé, started by the United States Government a number of years ago, and since standing in an uncompleted condition.

REASONS IN BRIEF.

With 1,200 miles of railroad completed within the bounds of the Territory by four different corporations, centering from as many different directions, within the past three years, with as many miles additional projected, much of the same under contract, and all giving strong assurances of early completion, has come to the Territory a corresponding immigration and business development. The necessities of the Territory consequently have immensely increased, and the demands upon public officers generally have grown far beyond the accommodations at command for office room, court rooms, and accommodations for the legislative assembly. Indeed, the accommodations now at command are but little better than at any time since the American occupation, while rents have largely increased. Thus, in view of the absolute necessities of the public service and of the large outlay for rents, securing but indifferent accommodations, I deem it a duty to urge upon you, and through you upon Congress, the prime necessity for prompt legislation, looking to the completion at an early day of the state-house at Santa Fé, N. Mex.

A word in addition, as a *question of policy*.

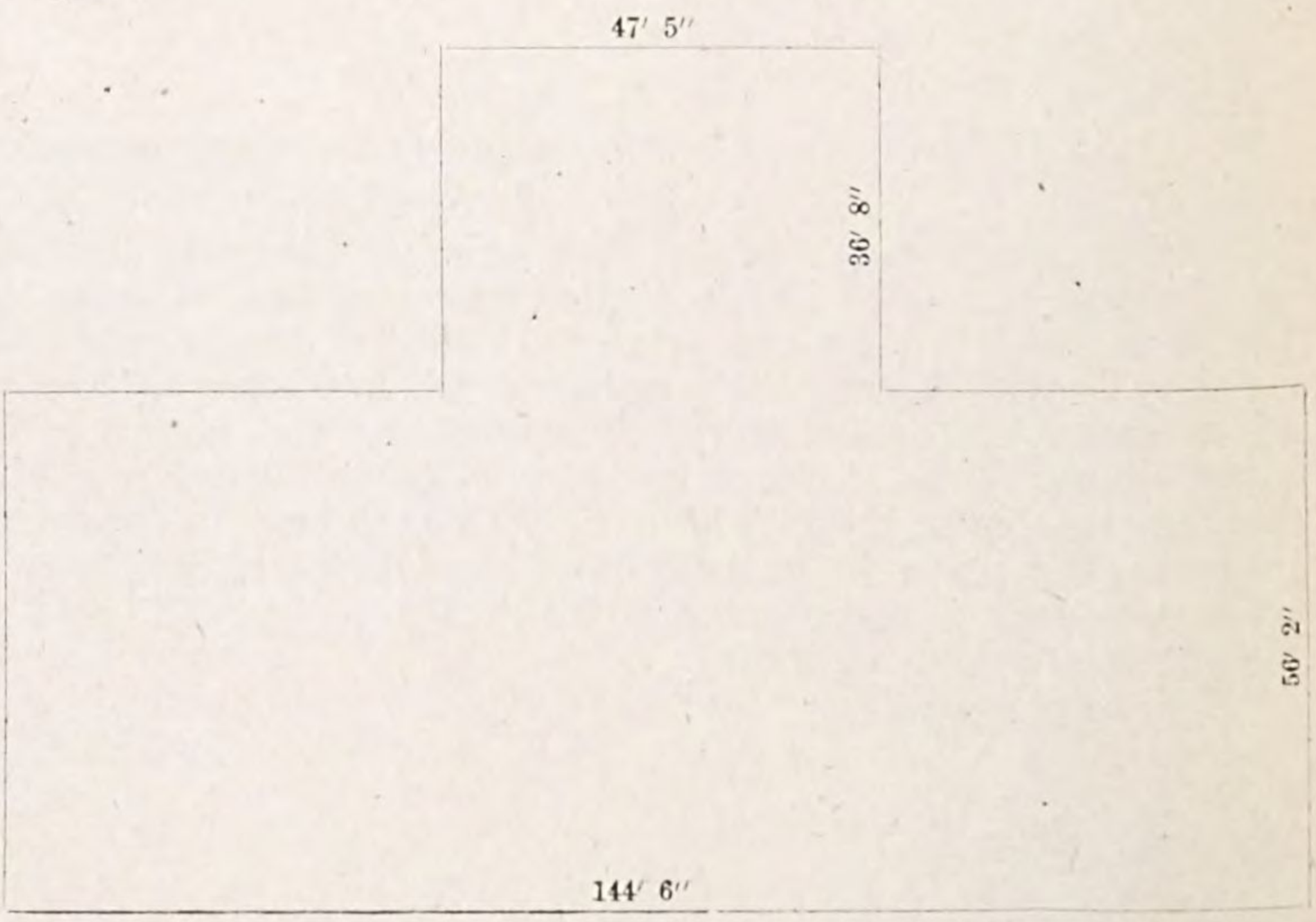
I take the liberty of calling your attention to the fact that the population of the Territory is largely of the Mexican race, and that they became citizens of the United States through the vicissitudes of the war of 1846–'48. Notwithstanding the situation, it is a remarkable fact that the great mass of these people have uniformly, since the American occupation, been friends to the general government. The loyalty of the people of New Mexico has nowhere been more pronounced than during the late war of the rebellion. This fact becomes at once patent when it is remembered that over 6,000 men voluntarily enlisted from our people into the Union armies, and that the decisive battle of the Rocky Mountain line of military operations, known as "Apache Cañon," or "La Glorieta," took place upon the soil of Central New Mexico.

No unusual appropriation has been since made in the interest of New Mexico. The appropriation asked for, necessary to complete the public buildings, would be but a trifle. As showing a substantial interest in this most important of all the Territories, the effect upon the people would be highly satisfactory. I submit that questions of public necessity and public policy alike should prompt the necessary appropriation by Congress for the completion of the state-house at Santa Fé, N. Mex.

I have the honor to be, most respectfully, your obedient servant,

W. G. RITCH,
Secretary of Territory and ex-officio Custodian of Public Buildings and Grounds.

Hon. H. M. TELLER,
Secretary of the Interior.



Informal specifications and estimate for the completion of the state-house at Santa Fé, Territory of New Mexico.

The "state-house building" at Santa Fé is a partially erected stone structure. The building faces south, is eligibly located upon the north side of the city and convenient to the plaza and business center. The lot, near the center of which the build- is located, is about 250 by 600 feet. The size upon the ground is 144.6 feet in length by 56.2 wide, with a rear wing, joining in the center, 36.8 by 47.5. The height of main building is about 22 feet, and comprises a basement with floor level with the ground, and the first story. The two flats are divided into vaults and offices with stone partitions. Fire-places and flues and suitable window and door openings are in place. The foundation is in a perfect condition and the superstructure generally good.

To raise the said building two stories higher, including a mansard roof, and to finish and complete the building, including plumbing and furnishings for water, light, and heating, would require the sum of $75,000.

Respectfully submitted.

W. G. RITCH,
Secretary of the Territory and Custodian of the Public Buildings and Grounds.

OFFICE OF THE SECRETARY OF THE TERRITORY,
Santa Fé, N. Mex., December 11, 1882.

47TH CONGRESS, 2d Session. } SENATE. { Ex. Doc. No. 28.

LETTER

FROM

THE POSTMASTER GENERAL,

TRANSMITTING,

In response to Senate resolution of December 21, 1882, *information relating to the postal routes in Dakota, from Fort Niobrara to Rapid City, and from Chamberlain to said Rapid City.*

DECEMBER 27, 1882.—Referred to the Committee on Post-Offices and Post-Roads and ordered to be printed.

POST OFFICE DEPARTMENT,
OFFICE OF THE POSTMASTER-GENERAL,
Washington, D. C., December 23, 1882.

SIR: I have the honor to acknowledge the receipt of the resolution adopted by the Senate on the 21st instant, in the following words:

Resolved, That the Postmaster-General be directed to inform the Senate why proposals have been invited for daily service from Fort Niobrara to Rapid City in Dakota; also daily service from Chamberlain to said Rapid City. Also, if both are new routes, and the distance of each. Also, if the proposed routes are not entirely through an Indian country, with no land open to settlement, and no whites residing therein, except those in the government service.

In reply, I have to state that proposals were invited for service on the two routes mentioned for two reasons: First, because it was represented by postmasters of the vicinage that the service was needed. Copies of such representations submitted herewith. And, second, because the department must know what the service would cost before it could properly decide whether or not to put it on.

Both routes are new, and were made post-routes by the act of August 7, 1882.

The distance from Fort Niobrara via Rosebud to Rapid City is 220 miles. From Chamberlain to Rapid City the distance is 186 miles.

I inclose with this a letter from the Hon. Secretary of the Interior, showing what portion of the two routes traverse Indian territory. This department has no knowledge of any white people residing within such Territory except those in the government service.

Very respectfully,

T. O. HOWE,
Postmaster-General.

The Hon. the PRESIDENT OF THE SENATE,
Washington, D. C.

U. S. POST-OFFICE DEPARTMENT,
OFFICE OF THE SECOND ASSISTANT POSTMASTER-GENERAL,
Washington, 17 *Aug.*, 1882.

SIR: By act of Congress approved Aug. 7, 1882, the following was established as a post-road in the State of Neb., viz: "From Fort Niobrara, Neb., to Deadwood, Dak."
(*The words of the law; the department has no other knowledge of the route*)
The Postmaster-General requests you to ascertain from the most authentic sources within your reach, and *without expense to the department*, the length of this route, and such facts in relation to the country through which it passes, its rivers, mountains (if any), as may be useful in preparing the advertisement inviting proposals for mail service on it and in locating it on the maps of the department, and for this latter purpose a diagram should be furnished, if practicable, and without expense. You are at liberty to submit any suggestions which occur to you in relation to the kind of service required, number of trips per week, days and hours of departures and arrivals, &c. The *length* of the route is quite important; please give it as correctly as possible.
If the track of the route is by existing offices, you will give their official names. Also name any local points not post-offices by which the route should run, giving distances from point to point.
Make your answer on this sheet and RETURN IT WITHOUT DELAY, under envelope addressed to this office.
Respectfully, &c., &c.,

R. A. ELMER,
Second Assistant Postmaster-General.

POSTMASTER, DEADWOOD,
Lawrence Co , Dak.

DEADWOOD, DAK., *August* 28, 1882.

Length of the above route, 265 miles.
Name in proper order points by which route should run: Fort Niobrara, Rosebud Agency, Pine Ridge Agency, Gifford's Ranche, Cheyenne Crossing, Lame Johnny Creek, Rapid, Deadwood.
How many trips a week are required?
On what day should mail leave your office?
At what hour?
On what day should mail reach the other end of route?
At what hour?
On what day should mail leave the other end of route?
At what hour?
On what day should mail arrive at your office?
At what hour?
Is this route, in your judgment, necessary for postal purposes? As far as Rapid, Dak.
If put in operation, what existing service, if any, could be dispensed with? None.
Give here any further information which you may deem important to be in possession of the department.
I have the honor to report the following in regard to the Fort Niobrara route. The distances and points are as follows: From Fort Niobrara via Munickadora to Rosebud Agency is 42 miles; from Rosebud Agency via Gifford's Ranche, on the old telegraph road, to Pine Ridge Agency is 100 miles; from Pine Ridge, following the same, the next nearest point is the Cheyenne Crossing of the government trail, to the interception of the Sidney road at Lame Johnnie's Creek, which is 50 miles; from thence to Rapid City, which is 28 miles, and from Rapid to Deadwood 45 miles. As to the time of leaving there, I am unable to name the hour.
Yours, respectfully,

J. A. HARDING, *P. M.*

[Indorsement.]

Sep. 29, '82.—That portion of route from Rosebud to Pine Ridge Agency has heretofore been found (Route 35102) impracticable. Advertise from Fort Niobrara direct to Rapid City via Rosebud. Topographer toe estimate distance.

LYMAN.

U. S. POST-OFFICE DEPARTMENT,
OFFICE OF THE SECOND ASSISTANT POSTMASTER-GENERAL,
Washington, 17 *Aug.*, 1882.

SIR: By act of Congress approved Aug. 7, 1882, the following was established as a post road in the State of Neb., viz: "From Fort Niobrara, Neb., to Deadwood, Dak."
(*The words of the law; the department has no other knowledge of the route.*)
The Postmaster-General requests you to ascertain from the most authentic sources

within your reach, and *without expense to the department*, the length of this route, and such facts in relation to the country through which it passes, its rivers, mountains (if any), as may be useful in preparing the advertisement inviting proposals for mail service on it and in locating it on the maps of the department, and for this latter purpose a diagram should be furnished, if practicable, and without expense. You are at liberty to submit any suggestions which occur to you in relation to the kind of service required, number of trips per week, days and hours of departures and arrivals, &c. The *length* of the route is quite important; please give it as correctly as possible.

If the track of the route is by existing offices, you will give their official names. Also name any local points not post-offices by which the route should run, giving distances from point to point.

Make your answer on this sheet and RETURN IT WITHOUT DELAY, under envelope addressed to this office.

Respectfully, &c., &c.,

R. A. ELMER,
Second Assistant Postmaster-General.

POSTMASTER, FORT NIOBRARA,
Sioux Co., Neb.

FORT NIOBRARA,
Sioux County, Nebraska, Aug. 26, 1882.

Length of the above route, 250 miles.

Name in proper order points by which route should run: Sharp's Ranch, Pine Ridge Indian Agency, Buffalo Gap, Rapid City, Fort Meade, Deadwood.

How many trips a week are required? Six.

On what day should mail leave your office? Daily, except Sunday.

At what hour? 7 a. m.

On what day should mail reach the other end of route? Daily, except Sunday.

At what hour? 7 a. m.

On what day should mail leave the other end of route? Daily, except Sunday.

At what hour? 7 a. m.

On what day should mail arrive at your office? Daily, except Sunday.

At what hour? 7 a. m.

Is this route, in your judgment, necessary for postal purposes? Yes.

If put in operation, what existing service, if any, could be dispensed with? Mail route, Fort Robinson to Deadwood; mail route, Fort Robinson to Pine Ridge Indian Agency; mail route, Fort Niobrara to Boiling Spring, could be cut down in distance about 25 miles, making a saving of about half.

Give here any further information which you may deem important to be in possession of the department.

This route runs from terminus of Sioux City and Pacific R. R. northwest, through settlements of Miniecadusa Valley to Sharp's Ranch; thence west, crossing south fork of White River three times, also Wounded Knee Creek, to Pine Ridge Indian Agency; thence west and northwest, crossing White River and south fork Cheyenne River, to Buffalo Gap; thence north (east of range of Black Hills) via Rapid City and Fort Meade to Deadwood City. This route is particularly needed, because points like Omaha, St. Louis, and the South generally, can be more quickly and cheaply supplied with mail service to and from the Black Hills. Rapid service is also needed between this military post (Ft. Niobrara) and Pine Ridge Agency. I will add that the road itself is considered a good hard one, open at all seasons of the year, excepting when unusually stormy. If service could be shortened to 36 hours, it is believed that the entire mail service from the Black Hills eastward would go by this route. Lt. Nickles, 5th Cav., lately made a military survey over most of this route. I have written him to send you a copy of his report.

J. M. THACHER, *P. M.*

U. S. POST-OFFICE DEPARTMENT,
OFFICE OF THE SECOND ASSISTANT POSTMASTER-GENERAL,
Washington, 17 *Aug.*, 1882.

SIR: By act of Congress approved 7 Aug., 1882, the following was established as a post-road in the Ter. of Dak., viz: "From Chamberlain to Rapid City."

(*The words of the law; the department has no other knowledge of the route.*)

The Postmaster-General requests you to ascertain from the most authentic sources within your reach, and *without expense to the department*, the length of this route, and such facts in relation to the country through which it passes, its rivers, mountains (if any), as may be useful in preparing the advertisement inviting proposals for mail service on it and in locating it on the maps of the department, and for this latter pur-

pose a diagram should be furnished, if practicable, and without expense. You are at liberty to submit any suggestions which occur to you in relation to the kind of service required, number of trips per week, days and hours of departures and arrivals, &c. The *length* of the route is quite important; please give it as correctly as possible.

If the track of the route is by existing offices, you will give their official names. Also name any local points not post-offices by which the route should run, giving distances from point to point.

Make your answer on this sheet and RETURN IT WITHOUT DELAY, under envelope addressed to this office.

Respectfully, &c., &c.,

R. A. ELMER,
Second Assistant Postmaster-General.

POSTMASTER, RAPID CITY,
Pennington Co., Dak.

Length of the above route, 213 miles, wagon road.

Name in proper order points by which routes should run: Rapid, Dak., down Rapid Valley to Cheyenne River, thence to Chamberlain.

How many trips a week are required? Seven trips a week.

On what day should mail leave your office? Every day.

At what hour? 7 a. m.

On what day should mail reach the other end of route? Every day, making trip in 48 hours.

At what hour? 7 a. m.

On what day should mail leave the other end of route? Every day in the week.

At what hour? 7 a. m., or on arrival Mil. & St. Paul R. R. train.

On what day should mail arrive at your office? Every day in the week.

At what hour? 7 a. m., making trip in 48 hours.

Is this route, in your judgment, necessary for postal purposes? It is.

If put in operation, what existing service, if any, could be dispensed with? None.

Give here any further information which you may deem important to be in possession of the department.

Enclosed please find diagram of the Chamberlain and Rapid City post-road. Three new offices should be established on this route along the Rapid Valley, at points marked in blue on diagram. This valley is 42 miles long via wagon from Rapid to Cheyenne River, and is thickly settled from the mouth to its head, Rapid being their nearest P. O.; Box Elder, Spring Creek, and Battle Creek, scattering settlements from the mountain to the Cheyenne River; country fast settling in all directions. Proposed post-offices on the Rapid 14 miles apart. Distance from Fort Niobrara to Rapid City, 155 miles; distance from Pine Ridge to Rapid City, 95 miles. Would recommend the establishment of a post-road from Fort Niobrara (present terminus of Sioux City and Pacific R. R.) to Rapid City, with branch to Pine Ridge.

* * * * * * *

Yours, respectfully,

JNO. R. BRENNO, P. M.

U. S. POST-OFFICE DEPARTMENT,
OFFICE OF THE SECOND ASSISTANT POSTMASTER-GENERAL,
Washington, 17 *Aug.*, 1882.

SIR: By act of Congress approved 7 Aug., 1882, the following was established as a post-road in the Ter. of Dak., viz: "From Chamberlain to Rapid City."

(*The words of the law; the department has no other knowledge of the route.*)

The Postmaster-General requests you to ascertain from the most authentic sources within your reach, and *without expense to the department*, the length of this route, and such facts in relation to the country through which it passes, its rivers, mountains (if any), as may be useful in preparing the advertisement inviting proposals for mail service on it and in locating it on the maps of the department, and for this latter purpose a diagram should be furnished, if practicable, and without expense. You are at liberty to submit any suggestions which occur to you in relation to the kind of service required, number of trips per week, days and hours of departures and arrivals, &c. The *length* of the route is quite important; please give it as correctly as possible.

If the track of the route is by existing offices, you will give their official names. Also name any local points not post-offices by which the route should run, giving distances from point to point.

Make your answer on this sheet and RETURN IT WITHOUT DELAY, under envelope addressed to this office.

Respectfully, &c., &c..

R. A. ELMER,
Second Assistant Postmaster-General.

POSTMASTER, CHAMRERLAIN,
Brule Co., Dak.

CHAMBERLAIN,
Brule County, Ter. of Dak., Sept. 20, 1882.

Length of the above route, 226 miles.

Name in proper order points by which route should run: Chamberlain, Bull Creek, Cheyenne Crossing, Box Elder, Rapid Creek, Rapid City. You go by Brule City Agency.

How many trips a week are required? It ought to be daily.

On what day should mail leave your office? Every day.

At what hour? 8 a. m.

On what day should mail reach the other end of route? Each day.

At what hour? Evening, 6 o'clock.

On what day should mail leave the other end of route? Same.

At what hour? Same.

On what day should mail arrive at your office?

At what hour?

Is this route, in your judgment, necessary for postal purposes? Yes, sir; it is needed very much.

If put in operation, what existing service, if any, could be dispensed with? None, without the route to Lower Brule and that to Fort Hale could be taken across the river, and taken with but little cost to the post and agency.

Give here any further information which you may deem important to be in possession of the department.

I submit herewith a letter as to the route, written by the engineer of the Mil. R. R., Kimball, who has been over the line.

There would be a large mail and express business spring up at once on this line. It would be a great thoroughfare, and the mail would mostly go that way, it being more direct from Chicago and the nearest route.

The Secretary of the Interior has now appointed the commission to treat with the Indians, and they will soon act, and their action will open a great country, and this route will be needed still more.

Yours,

JOHN H. KING, P. M.

Letter from Kimball, referred to above, does not appear on dep't files.

47TH CONGRESS, 2d Session. } SENATE. { EX. DOC. No. 29.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING,

In response to Senate resolution of December 13, 1882, *a report of the Chief of Engineers concerning the condition and progress of the work of the improvement of Charleston Harbor.*

JANUARY 4, 1883.—Referred to the Committee on Commerce and ordered to be printed.

WAR DEPARTMENT,
Washington City, January 3, 1883.

SIR: In response to Senate resolution of the 13th of December, 1882, which provides "that the Secretary of War be directed to furnish the Senate with such information as he may have in his possession, or may be able to obtain, as to the condition and progress of the work of the improvement of Charleston Harbor; and also if the money appropriated by the act of August second, eighteen hundred and eighty-two, is now being expended, and at what rate, and what balance may probably remain from that appropriation unexpended at the expiration of the present fiscal year," I have the honor to transmit herewith a report of the Chief of Engineers, dated December 30, 1882, and a copy of a report dated December 27, 1882, from Capt. James C. Post, Corps of Engineers, which, it is believed, comprise the information called for.

Very respectfully, your obedient servant,

ROBERT T. LINCOLN,
Secretary of War.

The PRESIDENT PRO TEMPORE
Of the United States Senate.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 30, 1882.

SIR: I have the honor to acknowledge the reference to this office, on the 14th instant, of the resolution of the Senate of the United States of December 13, 1882, directing the Secretary of War "to furnish the Senate with such information as he may have in his possession, or may be able to obtain, as to the condition and progress of the work of the improvement of Charleston Harbor; and also if the money appropriated by the act of August second, eighteen hundred and eighty-two. is

now being expended, and at what rate, and what balance may probably remain from that appropriation unexpended at the expiration of the present fiscal year," and, in reply thereto, to submit the inclosed copy of the report thereon from Capt. James C. Post, Corps of Engineers, to whom it was referred, which, it is hoped, will furnish the information called for.

The resolution is herewith returned.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers, Brig. and Bvt. Maj. Gen.

Hon. ROBERT T. LINCOLN,
Secretary of War.

IMPROVEMENT OF CHARLESTON HARBOR, SOUTH CAROLINA.

UNITED STATES ENGINEER OFFICE,
New York, December 27, 1882.

GENERAL: I have the honor to acknowledge the receipt of letter from office of the Chief of Engineers, dated 18th instant, inclosing a copy of the resolution of the Senate of the United States of December 13, 1882, and directing an early report thereon.

The resolution is as follows:

Resolved, That the Secretary of War be directed to furnish the Senate with such information as he may have in his possession, or may be able to obtain, as to the condition and progress of the work of the improvement of Charleston Harbor; and also if the money appropriated by the act of August second, eighteen hundred and eighty-two, is now being expended, and at what rate, and what balance may probably remain from that appropriation unexpended at the expiration of the present fiscal year.

I have the honor to report that since December, 1878, operations for improving the entrance into Charleston Harbor, South Carolina, have been carried on in accordance with the plan submitted by Lieut. Col. Q. A. Gillmore, Corps of Engineers, U. S. A., in his communication to the Chief of Engineers dated March 9, 1878, and printed in appendix H of the Annual Report of the Chief of Engineers for 1878.

By this project it is designed to establish and maintain by two jetties a low-water channel of not less than 21 feet depth across the bar, upon which the greatest available depth has heretofore been only 11½ feet.

The estimated cost of the project is $1,800,000.

The jetties are named the north jetty and south jetty, respectively. The north jetty has its shore end on Sullivan's Island; the south jetty, on Morris Island.

The seaward end of the foundation course of the north jetty has now reached a point 14,361 feet distant from the shore of Sullivan's Island, measured along the axis of the work, and about 1,000 feet inside the 18-foot curve of low-water depths on the outer slope of the bar.

The crest of the work rises from 2½ to 4 feet above the original bottom. The total amount of riprap stone thus far placed on the north jetty is 93,902 cubic yards. This stone rests upon log and brush mattresses, about 18 inches in thickness, aggregating 144,077 square yards.

On November 30, 1882, the seaward end of the apron of the south jetty was 11,024 feet from the shore of Morris Island, measured along the axis of the work, and about 1½ miles from the outer 18-foot curve of low-water of the bar.

The aggregate height of the work varies from 3 to 6 feet.

Since the beginning of operations on the south jetty, and up to November 30, 1882, the entire amount of material used upon this work was 44,478 cubic yards of riprap stone, and 116,070 square yards of log and brush mattresses, averaging 18 inches in thickness.

The work as far as constructed is generally in a satisfactory condition, notwithstanding some slight settlement has occurred at different periods at several portions of both jetties. Thus far nothing of a serious nature has taken place. At other points sand is collecting over the work, aiding in protecting the mattress logs from the attacks of the teredo.

Considerable scour has recently been observed alongside of and past the seaward portion of the south jetty. This has not only necessitated the construction of spur jetties on either side of it, but also indicates the expediency of a rapid seaward extension of the work, to guard against an undue increase of its ultimate cost.

To expend the sum of $300,000 appropriated for improving the entrance to Charleston Harbor, by act of Congress passed August 2, 1882, a contract was entered into, on September 30, 1882, with Mr. A. Ames Howlett, of Syracuse, N. Y., who agreed to do at least $25,000 worth of work per month.

Operations under this contract were commenced during the latter part of October last, and are now progressing. It is calculated that of said appropriation not more than $50,000 will remain unexpended at the end of the present fiscal year, and it is probable that the entire sum will be expended by the first of the following August.

It should be stated that, while the future ship-channel proposed to be developed and protected by the jetties is not yet formed nor available for the passage of large vessels, though some important changes are taking place, the existing or Pumpkin Hill Channel shows unmistakable signs of deterioration, caused no doubt by the influence of the works now in progress. A further reduction of the depths of this channel may be reasonably expected. It seems, therefore, to be of great importance, if not of urgent necessity, to promote the formation of the new ship-channel, not only by pushing out and raising both jetties as rapidly as possible, but also to hasten this effect by dredging, so that increased depths may be obtained at an early date. The increase gained in this manner will undoubtedly be substantially maintained by the jetties if the latter are simultaneously extended and strengthened.

The present appropriation is not sufficient to carry the work through this critical stage, and it is therefore greatly to be desired that an additional sum be made available for the coming fiscal year in order to prevent a suspension of operations.

Should this latter take place, it would undoubtedly cause a very material increase in the cost of this work, and seriously jeopardize even the present inadequate facilities for commerce. As was stated in the last annual report of Lieut. Col. Q. A. Gillmore, Corps of Engineers, $755,000 can be profitably expended during the fiscal year ending June 30, 1884.

Very respectfully, your obedient servant,

JAMES C. POST,
Captain of Engineers.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

47TH CONGRESS, 2d Session. | SENATE. | EX. DOC. No. 30.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING

A communication from the Secretary of War of the 2d instant, inclosing one from Lieut. Robert Craig, Fourth Artillery, recommending the printing and binding of ten thousand copies of the Annual Report of the Chief Signal Officer for 1882.

JANUARY 5, 1883.—Read and referred to the Committee on Military Affairs and ordered to be printed.

To the Senate and House of Representatives :

I transmit herewith for the consideration of Congress a communication from the Secretary of War, dated the 2d instant, inclosing one from Lieut. Robert Craig, Fourth Artillery, indorsed by the Chief Signal Officer of the Army, recommending that Congress authorize the printing and binding, for the use of the Signal Office, of 10,000 copies of the Annual Report of the Chief Signal Officer for the fiscal year 1882, and inclosing a draft of a joint resolution for the purpose.

CHESTER A. ARTHUR.

EXECUTIVE MANSION, *January* 5, 1883.

WAR DEPARTMENT,
Washington City, January 2, 1883.

SIR: I have the honor to transmit herewith, with request for their transmission to Congress, copy of a letter, of the 22d ultimo, from Lieut. Robert Craig, Fourth Artillery, bearing a copy of an indorsement of approval by the Chief Signal Officer of the Army, recommending that Congress authorize the printing and binding, for the use of the Signal Office, of 10,000 copies of the Annual Report of the Chief Signal Officer for the fiscal year ended June 30, 1882, together with a draft of a joint resolution for the purpose.

Very respectfully, your obedient servant,

ROBERT T. LINCOLN,
Secretary of War.

The PRESIDENT.

WAR DEPARTMENT,
OFFICE OF THE CHIEF SIGNAL OFFICER,
Washington City, December 22, 1882.

SIR: I have the honor to recommend that the honorable the Secretary of War may cause Congress to be requested to authorize the printing and binding of 10,000 copies

of the Annual Report of the Chief Signal Officer for the fiscal year ending June 30, 1882, and inclose herewith duplicate copies of draft of resolution, that Printing Committee of the House of Representatives and Senate may each be supplied with a copy, to enable a simultaneous action to be taken by both.

I am, very respectfully, your obedient servant,

ROBT. CRAIG,
First Lieutenant, Fourth Artillery,
Property and Disbursing Officer, Signal Service, U. S. A.,
Acting Signal Officer and Assistant.

The CHIEF SIGNAL OFFICER, U. S. A.,
Washington, D. C.

[Indorsement.]

OFFICE CHIEF SIGNAL OFFICER,
Washington, D. C., December 27, 1882.

Respectfully forwarded to the honorable the Secretary of War, approved.

W. B. HAZEN,
Brigadier and Brevet Major-General, Chief Signal Officer, U. S. A.

JOINT RESOLUTION authorizing the printing and binding of additional copies of the Report of the Chief Signal Officer.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Public Printer be, and he is hereby, authorized to print and bind, for the use of the Signal Office, ten thousand additional copies of the Annual Report of the Chief Signal Officer for the year eighteen hundred and eighty-two; and the Public Printer is authorized to contract for the illustrations with the person now furnishing the illustrations for the Congressional edition.

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47TH CONGRESS, 2d Session. } SENATE. { EX. DOC. No. 31.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING

A communication from the Secretary of the Interior, together with a letter of the Superintendent of the Census, requesting an additional appropriation of $100,000 to complete the work of the Tenth Census.

JANUARY 5, 1883.—Read and referred to the Select Committee on Tenth Census and ordered to be printed.

To the Senate and House of Representatives:

I transmit herewith a communication from the Secretary of the Interior, together with a letter of the Superintendent of the Census, requesting an additional appropriation of $100,000 to complete the work of the Tenth Census, and recommend the same to Congress for its favorable consideration.

CHESTER A. ARTHUR.

EXECUTIVE MANSION,
January 5, 1883.

DEPARTMENT OF THE INTERIOR,
Washington, January 4, 1883.

SIR: I have the honor to transmit herewith a communication from the Superintendent of the Census, dated the 2d instant, in which he sets forth the necessity for a deficiency appropriation of $100,000 for the completion of the work of the Tenth Census, and beg leave to recommend that the same be forwarded to Congress for its favorable consideration.

Very respectfully,

H. M. TELLER,
Secretary.

The PRESIDENT.

DEPARTMENT OF THE INTERIOR,
CENSUS OFFICE,
Washington, D. C., January 2, 1883.

SIR: In the absence of the Superintendent, but by his direction, I have the honor to submit for your consideration and action an estimate for an appropriation to enable this office to bring to publication within the present fiscal year the fifteen quarto volumes in which will be comprised the final report of the Tenth Census.

The Superintendent, under date of May 22, 1882, submitted to you an estimate in the sum of $245,000 for the completion of this work. That estimate was based in large part upon reports of special agents, in charge of certain branches of the general work, as to the progress and condition of the subjects in their hands, which had not received the personal inspection and revision of the Superintendent.

Subsequent experience has shown that underestimates were made by them of the time necessary to complete their labors.

It may be remarked, also, that since the date of the Superintendent's last estimate the publication of the compendium in advance of the quarto volumes was determined upon, and the time consumed in preparing matter for that volume has exceeded by at least two months the calculation made therefor. All the text and tabular matter for the compendium will be in the hands of the Public Printer by Saturday of this week (January 6). In rapid succession the quarto volumes will be pushed to publication, and it may be confidently predicted that by the 1st of June, 1883, fourteen of the fifteen final volumes, of 1,000 pages each, will have been issued, and the last volume will be ready for the Public Printer.

For payment of the force necessary to accomplish this purpose and to complete the work of the Tenth Census, it is estimated that a further appropriation, in the sum of $100,000, as a deficiency for the present fiscal year, will be required.

Very respectfully,

GEO. W. RICHARDS,
Acting Superintendent of Census.

Hon. H. M. TELLER,
Secretary of the Interior.

47TH CONGRESS, 2d Session. } SENATE. { EX. DOC. No. 32.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING,

In compliance with the requirements of the river and harbor act of August 2, 1882, a report of the Mississippi River Commission, with accompanying papers and maps.

JANUARY 2, 1883.—Referred to the Committee on Printing.

WAR DEPARTMENT,
Washington City, December 29, 1882.

The Secretary of War has the honor to transmit to the United States Senate a report of the Mississippi River Commission, with accompanying papers and maps, submitted in compliance with the requirements of the river and harbor act of August 2, 1882.

The Commission, in their letter forwarding said report, &c., to this department, express their desire to obtain one thousand copies thereof, and it is respectfully recommended that, in view of the valuable information contained in the report, it be ordered to be printed.

ROBERT T. LINCOLN,
Secretary of War.

The PRESIDENT *pro tempore*
of the United States Senate.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, December 1, 1882.

SIR: The Mississippi River Commission have the honor to submit the following report, embracing the subjects and subdivisions specified below, to wit:

1. Progress of surveys and examinations since October 10, 1881.—Detailed statements of expenditures from the appropriations for those purposes, and estimate of funds for continuing this work during the next fiscal year.

2. Construction.—Detailed statements of expenditures from the appropriation of March 3, 1881, and from the appropriation of August 2, 1882, to this date, with estimates for the next fiscal year.

3. Remarks on the subjects of levees and outlets.

4. Legislation.

5. References to miscellaneous appendices submitted with this report

PROGRESS OF SURVEYS AND EXAMINATIONS.

Pursuant to the requirements of the third section of the law organizing the Commission, and in accordance with the programme outlined in the report of March 6, 1880, surveys and examinations have been continued during the past year. The report of November 25, 1881, noted the progress made in this branch of the Commission's work to October 10, 1881, from which date to December 1, 1882, further progress is now reported.

Gauges.—Daily readings have been continued at the stations established by the Commission, which, with readings collected from other sources, have been collated and plotted for comparison and study.

Triangulation.—No field-work has been done since last report. The work previously executed has been partly adjusted and reduced.

Precise levels.—A line 90 miles in length has been run to connect the levels of the Coast Survey at Carrollton, La., with the tide-gauge on Mississippi Sound, the establishment of which was noted in last report and which has since been in continuous operation. A line has also been run from Keokuk, Iowa, northward along the river to a point opposite Clinton, Iowa, a distance of about 170 miles. The final reduction of 450 miles previously run has been made in the office.

The completion of the series of tide-gauge records and the determination of mean Gulf level therefrom, which will require but a few months, will make available the data necessary to determine with accuracy the elevations above Gulf level of all points along the Mississippi River from Clinton, Iowa, to New Orleans, a distance of more than 1,600 miles.

Final topography and hydrography, the former, embracing a strip of land averaging nearly a mile in width on each bank of the river, has been completed from Saint Louis Landing to a point about 10 miles above Vicksburg, a distauce of 255 miles; from Warrenton, 8 miles below Vicksburg, to Thrasher's Point, a distance of 25 miles, and from Natchez to Hutchins's Landing, a distance of 18 miles, making a total of 298 miles of river surveyed. Charts of the river (scale of $\frac{1}{10000}$) from Saint Louis Landing to Arkansas City, and from Greenville to Lake Providence, 27 in number, and covering 160 miles of river, have been plotted in the office.

The preparation of the preliminary chart (one inch to a mile) has been continued, ten sheets having been drawn, making fourteen in all, and eleven published, extending from Cairo to Saint Louis Landing, 360 miles. The charts of the Mississippi River from Donaldsonville to the Passes, 175 miles. have been reduced to the same scale in six sheets, of which five have been published. The reduction was made by the Coast and Geodetic Survey at the expense of the Commission.

Observations.—Daily discharge measurements were made from December, 1881, to December, 1882, at Paducah, on the Ohio River, and at Columbus, Helena, Hay's Landing, and Red River Landing on the Mississippi River. The parties engaged in this work were also charged with special studies of the effect of the flood on the bed and channel of the river. The value of these observations is very much enhanced by the fact that the flood which occurred during their continuance was of unprecedented magnitude.

In conjunction with the above work, three parties were sent over the river from Cairo to Baton Rouge at the top of the flood, to obtain the fullest and best possible data as to the escape of water from the river by flow over banks and through outlets and crevasses, and also to investigate the amount and direction of the discharge through the swamps.

The final reduction of the observations of last year on the Upper Mississippi and a part of the above mentioned has been made in the office.

High-water marks and slope.—Two parties are now in the field, one engaged in determining elevations of the floods of 1881 and 1882, the other in determining the slope of the river at the present low water from Commerce Cut-off to Natchez, a distance of 400 miles.

Trans-alluvial levels.—The flood of last year compelled a suspension and retarded the completion of the lines designed to give needed information as to the heights of the alluvial bottom lands and their reservoir capacity. The party is again in the field and will probably complete the lines during the present season.

In addition to the usual financial statement, itemized statements of expenditures from the appropriations of June 30, 1879, June 16, 1880, and March 3, 1881, will be found below.

The following papers relating to the work of surveys and examinations are submitted as appendices to this report:

Appendix A.—Annual report of the Secretary of the Commission upon the field-work of surveys.

Appendix B.—Report upon, and final results of, secondary triangulation from Helena Island to Greenville.

Appendix C.—Report upon, and final results of, precise leveling from Friar's Point to Greenville, and from Cairo to Columbus.

Appendix D.—Report upon observations at Lake Providence, Louisiana, from November, 1879, to November, 1880.

Appendix E.—Report upon observations at Carrollton from December, 1879, to November, 1880.

Appendix F.—Results of observations at six stations on the Upper Mississippi River, from October, 1880, to October, 1881.

Appendix G.—Report upon field-work of topography.

FINANCIAL STATEMENT.

Balance on hand July 1, 1882	$38,005 72	
Appropriated by act approved August 2, 1882	150,000 00	
		$188,005 72
Expended from July 1, 1882, to December 16, 1882, including estimated liabilities	96,224 84	
Balance which it is estimated will be required during remainder of fiscal year ending June 30, 1883	91,780 88	
		188,005 72

Itemized statement of expenditures for surveys and expenses of Mississippi River Commission.

[Appropriation of June 30, 1879.]

	Services assistant engineers.	Services rodmen and other employés.	Outfit.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Mileage.	Miscellaneous.	Total.
Borings	$1,446 00	$1,758 00	$565 89	$121 61	$664 88	$9 00	$400 00	$778 49		$57 05	$5,800 92
Coast and Geodetic Survey											16,666 74
Commissioners' salaries											8,774 99
Mileage and inspection		5,200 92	104 07	407 20	2,143 92	3,586 42	602 74	315 83	$3,825 39		16,186 49
Hydrography and topography	4,332 92	6,111 47	646 15	257 00	1,934 35	585 03	568 54	538 46		$631 76	15,605 68
Gauges	290 00	992 75	267 00	43 87				230 90			1,824 52
Levels, precise	2,349 00	2,993 73	278 44	71 65	985 82		309 02	375 34		263 65	7,626 65
Observations	7,829 00	14,224 84	650 34	1,670 85	4,832 17	1,914 18	1,440 88	1,033 12		82 70	33,678 08
Reduction of maps		2,667 00						3 70			2,670 70
Triangulation	7,750 67	10,403 71	1,069 10	307 10	3,890 60	652 72	675 46	2,196 24		1,268 41	28,208 01
Statistical reports											600 00
Instruments											2,437 00
OFFICE EXPENDITURES.*											
Services assistant engineers											1,375 50
Services clerks, &c											3,319 56
Rent											842 00
Fuel											155 81
Furniture											718 92
Stationery											847 37
Drawing materials and supplies											376 34
Transportation											49 60
Professional works and charts											96 52
Miscellaneous											486 66
Totals	23,997 59	44,352 42	3,580 99	2,879 28	14,451 74	6,747 35	3,996 64	5,466 08	3,825 39	2,303 57	148,348 06

*Office expenditures embrace all note-books, drawing materials, and stationery used in the field, general office, and office of the president.

SUMMARY.

Appropriated by act June 30, 1879	$175,000 00
Cash deposited, overpayment voucher	5 00
Total	175,005 00
Expenditures for fiscal year ending June 30, 1880	148,348 06
Balance	26,656 94

SMITH S. LEACH.

First Lieutenant of Engineers, Secretary and Disbursing Officer Mississippi River Commission.

Itemized statement of expenditures for surveys and expenses of Mississippi River Commission.

[Appropriation of June 16, 1880.]

	Services assistant engineers.	Services rodmen and other employés.	Outfit.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Mileage.	Miscellaneous.	Totals.
Copying maps	$97 50	$288 00									$385 59
Borings	199 08										199 08
High and low water marks	2,177 00	1,902 59	$68 90	$144 73	$579 94	$141 89	$110 90	$222 61		$33 30	5,381 86
Contingencies											325 65
Commissioners' salaries											8,500 00
Mileage and inspection		2,202 16		125 22	1,043 87	1,208 85		99 20	$4,884 98		9,564 28
Transverse valley levels	1,647 67	1,069 50	31 42	8 10			10	263 95		18 95	3,039 69
Hydrography and topography	8,808 50	4,966 44	1,062 74	392 17	1,999 23	137 60	587 03	1,462 40		956 87	20,372 98
Gauges		2,181 00	89 00	2 63			5 00	46 60			2,324 23
Instruments											1,852 54
Levels, precise	4,075,00	5.571 69	35 12	284 24	1,871 98		41 00	897 25		543 63	13,319 91
Triangulation	5,653 00	8,361 09	1,143 60	532 28	2,737 87	355 25	667 57	1,276 20		1,288 88	22,015 74
Observations	14,191 00	17,374 86	823 10	1,928 31	2,262 54	769 85	139 61	1,051 78		654 07	39,195 12
Meter testing	455 17	104 60	29 10	89 56			5 00	2 85			686 28
OFFICE EXPENDITURES.*											
Services assistant engineers											3,732 28
Services clerks, &c											5,678 07
Rent											1,488 00
Fuel											401 81
Furniture											148 50
Stationery											507 19
Drawing materials and supplies											521 67
Transportation											164 25
Professional works and charts											454 90
Miscellaneous											507 95
Totals	37,303 92	44,021 93	3,282,98	3,507 24	10,495 43	2,613 44	1,556 21	5,322 84	4,884 98	3,495 70	140,767 48

* Office expenditures embrace all note-books, drawing materials, and stationery used in the field, general office, and office of the president.

SUMMARY.

Balance from appropriation June 30, 1879	$26,656 94
Appropriated by act of June 16, 1880	150,000 00
Cash deposited, sale of fuel to officers, &c	55 50
Total	176,712 44
Expenditures for fiscal year ending June 30, 1881	140,767 48
Balance	35,944 96

SMITH S. LEACH,

First Lieutenant of Engineers, Secretary and Disbursing Officer Mississippi River Commission.

Itemized statement of expenditures for surveys and expenses of Mississippi River Commission.

[Appropriation of March 3, 1881.]

	Services assistant engineers.	Services rodmen and other employés.	Outfit.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Mileage.	Miscellaneous.	Total.
Copying maps		$131 67									$131 67
High and low water marks	$925 00	6 70		$2 30				$152 40			1,086 40
Triangulation	1,398 00	2,825 83	$2 75	216 93	$305 03	$86 06	$48 00	353 00		$273 50	5,509 10
Hydrography and topography	18,900 08	14,543 00	371 11	874 83	5,923 66	1,073 65	502 27	1,451 53		2,815 55	46,455 68
Levee maps	66 67										66 67
Contingencies		600 75									600 75
Commissioners' salaries											9,500 00
Mileage and inspection		2,010 73	99 15	260 76	1,614 31	1,351 68	215 75	3 25	$5,201 12	16 05	10,772 80
Transverse valley levels	1,440 00	1,991 50	35 44	27 92			13 70	205 95		17 40	3,731 91
Flood observations	140 00	1,416 99	87 70	115 12	167 59	110 40	320 52	242 90		19 25	2,620 47
Gauges		2,347 00					2 00				2,349 00
Tide-gauge connection	324 67	727 34	20 00	8 10				105 15		5 00	1,190 26
Levels, precise	1,045 00	1,640 84		39 58	386 03			135 70		152 60	3,399 75
Observations	12,692 00	15,722 71	9,682 58	2,376 10	7 20	628 87	1,548 55	1,408 03		492 56	44,558 60
Reduction of maps		267 75									267 75
Publication of maps											1,954 25
OFFICE EXPENDITURES.*											
Services assistant engineers											894 67
Services clerks, &c											9,182 12
Rent											1,200 00
Fuel											339 55
Furniture											16 00
Stationery											369 47
Drawing materials and supplies											862 82
Transportation											360 32
Professional works and charts											40 28
Miscellaneous											565 07
Totals	36,931 42	44,232 81	10,298 73	3,921 64	8,403 82	3,250 66	2,650 79	4,057 91	5,201 12	3,791 91	148,025 36

* Office expenditures embrace all note books, drawing materials, and stationery used in the field, general office, and office of the President.

SUMMARY.

Balance from appropriation June 16, 1880	$35,944 96
Appropriated by act March 3, 1881	150,000 00
By cash deposited, sale of fuel to officers, &c	86 12
Total	186,031 08
Expenditures for fiscal year ending June 30, 1882	148,025 36
Balance	38,005 72

SMITH S. LEACH,

First Lieutenant of Engineers, Secretary and Disbursing Officer Mississippi River Commission.

ESTIMATE OF FUNDS FOR SALARIES AND EXPENSES OF THE COMMISSION FOR NEXT FISCAL YEAR.

To continue the "surveys of the Mississippi River between the Head of the Passes near its mouth and its head waters, now in progress"; to make "additional surveys and examinations of said river and its tributaries"; to make such additional examinations and investigations, topographical, hydrographical, and hydrometrical, as are necessary for maturing a plan for the permanent improvement of the entire river; for salaries and expenses of the Commission in traveling, mileage and inspection, for office expenses, computing, draughting, &c., and for publication of maps and results..... $200,000

CONSTRUCTION.

At the date of the last annual report of the Commission surveys were in progress on the Plum Point and Lake Providence Reaches, preparatory to a definite location of the works of improvement contemplated. The preparation of plant was progressing favorably and materials of all kinds were being collected. Parties had been set to work on both reaches to clear the standing timber from banks where revetment work was contemplated, and arrangements had been made to borrow from the works near Saint Louis a number of pile drivers for use while those ordered by the Commission were being completed. It was fully anticipated at the time that work would speedily be commenced and be pushed vigorously during the winter. These expectations were unfortunately not realized. In the latter part of November a heavy rise set in, filling the river to the top of its banks. This was followed by several others, culminating finally in a flood which, for height, duration, and wide-spread destruction, is without a parallel. Nearly the whole valley was deeply submerged, and the river remained either out of its banks or at too high a stage for effective work till July of the present year. During this period but little work could be done, and such as was done was only expected to avert undesirable changes in the channel. The necessarily great expense of this work and the cost of constructing and maintaining the extensive plant and equipment required had practically exhausted the appropriation at the end of the fiscal year, and all work was then suspended until the new appropriation became available (the river and harbor bill not having become a law till August 2, 1882). As soon as possible work was resumed and has been in progress ever since, though the results so far accomplished have fallen very much short of even reasonable anticipations. The difficulty has lain in the absolute impossibility of obtaining the necessary labor. When the floods of last winter and spring had subsided the swamps were left full of water, which drained off but slowly, and, in consequence of this, malarial diseases have prevailed along the river to an unusual extent. The local supply of labor is scanty and unreliable, especially during the cotton-picking season, and it was not found possible, nor was it deemed desirable, to import labor from the North until the sickly season was over. Later on, the extensive levee construction along the river was a formidable competitor. In consequence of this the works which require from one to two thousand men for their efficient prosecution have been carried along by small gangs of from one to two hundred men, with correspondingly meager results. Happily, this trouble seems now at an end; labor is coming in freely, and no further difficulty is anticipated from this source.

By the act passed August 2, 1882, the Commission was relieved of the responsibility of carrying on the works directly, and by the decision of the honorable the Secretary of War this is now in charge of the

Engineer Department of the Army, under the general supervision of the Commission. Upon their recommendation the river below Cairo has been divided into four administrative districts, each in charge of an officer of Engineers, under whose direction all improvement works of any kind in the district are carried on. These districts are as follows:

First district.—Cairo to foot of Island No. 40, 220 miles, in charge of Capt. J. G. D. Knight, United States Engineers. Headquarters, Cairo, Ill.

Second district.—Foot of Island No. 40 to mouth of White River, 180 miles, in charge of Capt. A. M. Miller, United States Engineers. Headquarters, Memphis, Tenn.

Third district.—Mouth of White River to Warrenton, Miss., 220 miles, in charge of Capt. W. L. Marshall, United States Engineers. Headquarters, Vicksburg, Miss.

Fourth district.—Warrenton, Miss., to Head of Passes, 484 miles, in charge of Maj. Amos Stickney, United States Engineers. Headquarters, New Orleans, La.

In addition, an officer of Engineers, Capt. C. B. Sears, who is stationed in Saint Louis, acts as executive officer of the Commission in matters pertaining to construction. He is also charged with the duty of purchasing for the works all supplies and materials which cannot be procured to advantage in the immediate neighborhood, with the construction of plant, the custody of all floating property, and with the management of the towing and transportation service.

Under the act of August 2, 1882, the Commission were charged with the prosecution of works at the following points heretofore carried on by special appropriations, with the exception of the fifth, which is a new work:

1st. Memphis Harbor.
2d. Vicksburg Harbor.
3d. Natchez Harbor.
4th. Rectification of Red and Atchafalaya Rivers.
5th Lock at Bayou Plaquemine.
6th. New Orleans Harbor.

The balances available for these works from previous appropriations were as follows:

At New Orleans	$110,000
At mouth of Red River	89,000
At Vicksburg (Delta Point)	27,000
At Natchez	7,800
At Memphis	400

Allotments have been made for Memphis and Vicksburg Harbors as described further on, and surveys have been ordered at Natchez and Bayou Plaquemine to determine the amount required for prosecuting the work at those points. At New Orleans and Red River the old balances available were deemed sufficient for present purposes.

Plans for the improvement at New Orleans have received the approval of the Commission, and work will be commenced there as soon as a favorable opportunity occurs.

At the mouth of Red River a new survey has been ordered to enable a decision to be made as to the best method of accomplishing the desired improvement.

In addition to continuing work on the Plum Point and Lake Providence Reaches the Commission have decided to begin work this season on the improvement of the New Madrid and Memphis Reaches as soon as the surveys now in progress are completed, and surveys have also been

ordered of the Helena and Choctaw Reaches in order to be prepared with plans for their improvement as soon as the necessary funds become available. This will complete the six reaches of most difficult navigation specified in the preliminary report of the Commission, the improvement of which in their opinion should be first undertaken.

The appropriation of $1,000,000, made by act approved March 3, 1881, was allotted as follows:

Improvement of Plum Point Reach	$600,000
Improvement of Lake Providence Reach	400,000

And at the date of our last report a balance from both allotments of $750,000 was available.

The appropriation of $4,123,000, made by act of August 2, 1882, has been allotted to date as follows, exclusive of levees:

New Madrid Reach	$700,000
Plum Point Reach	700,000
Memphis Reach and Harbor	325,000
Lake Providence Reach	650,000
Vicksburg Harbor (Delta Point)	50,000
Vicksburg Harbor (dredging)	100,000
Survey of Helena Reach	8,000
Survey of Choctaw Reach	4,000
Observations at Carrollton	3,000

Detailed statements of the expenditures to date under both appropriations accompany this report.

The act of August 2, 1882, furthermore placed under the supervision of the Commission the improvement of the Mississippi River between the mouths of the Illinois and Ohio Rivers, upon which work has for several years been in progress under the direction of the Engineer Department, United States Army. The Commission were authorized to accept for such portions of the river not covered by their own surveys, any plans prepared by the Engineer Department, approved by the Secretary of War, which might meet with their approval. The Commission personally examined the portions of the river in question, and after conference with Majors Mackenzie and Ernst, United States Engineers, the officers in charge of the work, their projects for the expenditure of the current appropriations were approved, and the work has been in progress until recently stopped by ice.

Estimates for the further prosecution of these works accompany the other estimates of the Commission. In both cases the Commission deemed it important that the annual appropriations be increased to enable the works to be pushed forward more rapidly, thus affording earlier relief to navigation. On both the works substantial benefit has already been conferred, and we see no reason for doubting the ultimate entire success of the improvement. On the Upper Missisippi, below the Des Moines, work has been carried on in detached portions, and so far only at those places where navigation is most impeded. This plan gives immediate relief, and the gentle and tractable character of the river allows of such treatment; but on the Mississippi below the junction of the Missouri the case is different, and only continuous work, beginning at some point of stable regimen, affords any prospect of success. This fact, with the additional motive of facility and economy of administration, has so far kept the work concentrated in the vicinity of Saint Louis, and it is being extended down stream annually as fast as the appropriations allow. It has, however, been represented to the Commission that this course of treatment works much hardship to the navigation interests, as there is no practical difference in the depth of

water available for vessels till the mouth of the Ohio is reached. At the present rate of progress it may require 10 or 12 years to carry the improvement to this point, during which period no great relief will be afforded, as boats can still only load to the depth of water afforded by the shoalest bar in the stretch of river under consideration. This argument has great force, but the engineering reasons in favor of the present policy are deemed too great to justify the Commission in recommending any departure therefrom as long as appropriations for the work are no larger than at present. As things now are the plant is proportioned to work to advantage and on the present system of appropriations as now made, but by doubling or trebling these one or two new sets of plant could be provided and work could be started at one or two new points. In that case the whole improvement could be completed in correspondingly shorter time and without increase of ultiinate cost. If provision were made for starting work at one other point, Grand Tower would probably be the most suitable one; if two were provided for, Chester and Commerce would be the proper initial points, the improvement in either case being carried continuously down stream. With this explanation of our estimate for this work, the matter is left for the decision of Congress.

WORKS BELOW CAIRO.

Before entering on a more detailed description of the operations of the past year below the mouth of the Ohio, it will be well to recapitulate the general features of the plan upon which the Commission have been working. It consists essentially in seeking to increase the navigable depth at low-water by narrowing the width at that stage to about 3,000 feet, it being found that where this width is exceeded bad navigation as a rule exists.

To accomplish this result recourse is had to light permeable structures erected in the river bed and designed by checking the velocity of the current, to induce deposits of sediment on those portions of the bed which it is proposed to reclaim from the river.

By a continuance of this action, which merely imitates the natural processes constantly at work, it is expected that these deposits will ultimately be raised to the level of the normal banks.

When this is done the river will have a nearly uniform width, and the tendency which now exists to form shoals in the wide places will be done away with.

At the same time the concentrated flow thus set up will scour down the bed, remove the present shoals, and ultimately to some extent lower the flood-line.

To prevent the constant bank erosion now going on, both the old banks and the new ones, where exposed to this action, must be protected by brush mattresses below the low-water line, and above that point by brush or stone or the natural vegetation.

The principle herein proposed of contracting the water-way to secure increased depth is in no sense experimental, but has been successfully carried out on many streams in this country and abroad.

The special methods proposed have also passed beyond the experimental stage; they have received practical tests at various points on the Mississippi and Missouri Rivers, and even the recent work done by the Commission already shows their correctness. They are only applicable to silt bearing streams.

The special devices used, that is, the details of permeable dikes and revetments are still matters of experiment, not so much as regards their

efficiency as their cost—an item of prime importance in a work of this magnitude.

To this point the earnest attention of the Commission and all engaged on the works is now being directed. It is, however, certain that no cheaper methods are known than those now proposed, and if they fail it is questionable whether the improvement of the Mississippi is financially possible.

It is yet too early to draw conclusions as to the cost of the work required. Such as has been done has been carried on under great difficulties; the men employed have had to receive instruction in all the details of the work, and, furthermore, the amount of work done has been too small to convey a fair idea as to its cost.

For these reasons we may confidently expect that the prices to date will never be exceeded, and will probably be considerably reduced.

The main item of cost will of course be the bank protection. The work so far done on the Plum Point Reach, has cost below low water about $3 per running foot, the upper bank protection not yet on will not exceed $9 per foot, making a total cost of bank per foot $12.

On the Lake Providence Reach the work below low water has cost $2.76 per foot, and, assuming the same cost as above for the upper bank, we have $11.76 per foot.

At Delta Point, where the work is extra strong and difficult, the work below low water has cost $3.86 per foot, the upper bank work has cost $10.14 per foot, making a total of $14 per foot.

As regards contraction works, the dikes on Lake Providence Reach have so far cost, complete with piles, foot-mats and screens, $3.50 per running foot.

The prices given are for recent work and do not include cost of plant.

FIRST DISTRICT.

(Cairo to foot of Island No. 40, 220 miles in length.)

This district embraces two reaches under improvement, viz, the New Madrid Reach, extending from the head of Island No. 8 to the foot of Island No. 14, a distance of 60 miles, and the Plum Point Reach, extending from the head of Island No. 26 to the head of Island No. 35, a distance of 40 miles. The head of the New Madrid Reach is 42 miles below Cairo; the head of Plum Point Reach, 147 miles below the same point.

NEW MADRID REACH.

A low-water survey of this reach is now in progress, and will probably be completed in December.

As soon as a plan can be matured, work will be commenced. The necessary plant for carrying on the work is under contract and well advanced towards completion.

PLUM POINT REACH.

Work was begun on this reach last year, though nothing much was accomplished until within the last few months, for reasons already al luded to. Prior to the high water the caving banks from above Island No. 26 to Craighead's Point were cleared of heavy timber preparatory to commencing the revetment. During the height of the flood the threatened destruction of Bullerton Tow-head called for active measures

for its protection, and work was started here. A line of pile A bents was constructed outside of the tow-head for a length of 2,400 feet, and a wire screen suspended therefrom; 540 feet of light mattress work was also placed on the head of the tow-head. This work, which was only expected to subserve a temporary purpose, was perfectly successful. It has since been replaced by more permanent structures.

As soon as the river got within its banks the pile-drivers were set at work to close the head of Osceola Chute with a line of braced piling, upon which it was proposed to hang brush screens, while a substantial foot-mat was to be placed outside to prevent scouring along or under the piling. The water was still too high for efficient work, and the enormous quantities of drift running prevented the laying of the foot-mat or even completing the line of piling. Finally the water running under the immense mass of drift which had collected against them scoured out the piles, and of 4,500 feet of pile-dike constructed 3,900 feet were carried away. This was entirely due to the failure to get in the foot-mat, of which only 570 feet could be constructed, but while the work held extensive deposits took place behind it, which are bare at a stage 8 feet above low water.

From June 9 to August 3, work was stopped, owing to lack of funds. At that date it was resumed and is still in progress. The pile-dike at the head of Osceola Chute has been reconstructed and properly completed as originally intended. A similar dike 2,244 feet long has been nearly completed across the middle chute through Osceola bar, and a similar one 3,000 feet long extends across from Bullerton to Osceola Tow-head, complete except for a gap where the present low-water channel leads in behind Bullerton Tow-head. This will be closed as soon as the river rises sufficiently to allow boats to run outside of the tow-head. A similar dike 5,273 feet long extends across the head of the chute behind Elmot Tow-head and Island No. 30. This dike has been carried as far as the stage of water will allow and is otherwise nearly completed.

As soon as possible cross-dikes will be placed across these various chutes, and the main lines will be completed.

Revetment has been begun near Ashport, and 2,694 feet of under-water mattress 138 feet wide is in place. At the head of Bullerton Tow-head 1,428 feet of under-water mattress 107 feet wide has been constructed.

Sickness, and the difficulty of procuring labor and materials, have greatly retarded the work.

For details of work in this district, see report of Capt. J. G. D. Knight, United States Engineers, Appendix J.

SECOND DISTRICT.

(Foot of Island No. 40 to mouth of White River, 180 miles.)

This district includes the Memphis and Helena Reaches, the first extending from the foot of Island No. 40, 220 miles from Cairo, to Scanlan's Island, a distance of 27 miles, and the second extending from Commerce Cut-off, 270 miles below Cairo, to Friar's Point, a distance of 55 miles.

The first reach includes Memphis Harbor.

MEMPHIS HARBOR.

Work at this point has been going on under the Engineer Department since 1878, under special annual appropriations, the object being

to stop the caving along the upper part of the city front. The means of protection used, brush mattresses, have been quite successful, and a recent examination by a diver shows them to be in a fair state of preservation. The officer in charge having reported that $25,000 would repair the old and complete the new work required, an allotment of that amount was made. Work was begun October 20, and is still in progress. To date, 14 mattresses, 120 by 60 by 2 feet, have been sunk, and one mattress, 120 by 40 by 2 feet; and the damage to the old work, due mainly to the landing of steamers against it, has been repaired. There still remains to grade the upper bank, and to cover it with brush and stone.

MEMPHIS REACH.

The survey of this reach is not quite completed. As soon as this is done and the plans are matured work will begin, the necessary plant being under construction and nearly ready.

It being important to prevent further deterioration in Memphis Harbor, due to the caving in Hopefield Bend and below Frame Chute, the Commission have authorized the revetment of the shore at these localities, work to be commenced as soon as possible.

HELENA REACH.

A survey of this reach has been ordered and is in progress. When completed, a plan for its improvement will be elaborated, so that no delay need be incurred in beginning the work whenever the funds at the disposal of the Commission will justify its inception. It should be the next in order to be taken up.

For details of work in this district, see report of Capt. A. M. Miller, United States Engineers, Appendix K.

THIRD DISTRICT.

(Mouth of White River to Warrenton, Miss., 220 miles.)

This district embraces the Choctaw Reach, extending from Cork's Point, Ark., 422 miles below Cairo, to Arkansas City, Ark., a distance of 31 miles; the Lake Providence Reach, extending from Carolina Landing, Miss., 530 miles below Cairo, to the foot of Island No. 95, a distance of 35 miles; and also the improvement of Vicksburg Harbor.

CHOCTAW REACH.

A survey of the reach has been ordered, and is in progress. When completed, a plan for its improvement will be matured, in order that work may be initiated as soon as the funds at the disposal of the Commission will justify.

LAKE PROVIDENCE REACH.

Work on this reach was begun early last year, and consisted mainly of clearing heavy timber from the caving banks, preparatory to revetment. During the great flood but little could be done; a few piles were driven on the shoalest portions of the lines which had been chosen; but the water was too deep for efficient work, and the heavy drift rendered the driving of piles extremely difficult. In all, during this period, 9,634 running feet of piling were driven on Baleshead Bar, and between the two tow-heads in front of Duncansby 586 feet of screens and foot mats were

placed, and about 23 miles of banks were cleared of timber. On July 1 work was suspended for lack of funds, and was not resumed till August 4, since which date it has made only fair progress, owing to causes which have been already enumerated. Sickness and lack of labor were the main difficulties. Even now but 500 men are employed, while 2,000 could be worked to advantage. The work contemplated on this reach embraces contraction works for nearly the entire length, designed to limit the width of waterway to about 3,000 feet, and revetment work in Carolina and Louisiana Bends, at Meyersville Island (No. 93), at Stack Island (No. 94), of the Louisiana shore from Vista to Dusona, and at Point Lookout. To date there has been constructed 23,284 linear feet of pile dike, 5,375 feet of brush screens, 7,329 feet of foot-mats, 375 feet of hurdle matting, and 1,719 feet of bank revetment, consisting of an underwater brush mattress along the face of Meyersville Island. The work in front of Skipwith's Landing, composed of dikes of piles supporting hurdle screens, is sufficiently advanced to show marked results, an area of about 2½ square miles having been so silted up as to go dry at low water. The contraction works are also complete behind Meyersville Island, and are being extended down towards Stack Island, the chute of which will be closed as soon as the depth of water will allow boats to use the outside channel. Preparations are being made to commence the bank revetment, and if we are spared an early flood, and labor can be obtained in sufficient quantity, rapid progress on this work may be looked for.

VICKSBURG HARBOR.

Work has been going on at this point for several years under the direction of the Engineer department, being prosecuted under special annual appropriations. Heretofore work has been entirely confined to the holding of Delta Point by revetment, the object being to prevent any further recession of the deep water of the river from the harbor proper of Vicksburg. This work has been in the main successful, though prosecuted under many difficulties which have greatly added to its cost. The balance of the old appropriation, $26,000, was inadequate to complete the work, and $50,000 additional has been allotted by the Commission. Work is being actively prosecuted at the present time, and the work is about half done. To date, 1,100 feet of shore have been substantially revetted, from the bottom of the river to the top of the bank, the mattress below low water being 150 feet wide. Above low water the bank is graded to a slope of 2¼ to 1 by hydraulic graders, then covered with a brush mattress 10 inches thick extending to the top of the bank and lapping well on to the lower mattress. This upper bank protection is to be covered with about one foot of stone. This work is the most substantial of any that the Commission have as yet undertaken and consequently the most costly. It is very improbable that the revetments ordinarily required will equal it in expense. The cost per running foot of bank so far completed is $14. The large hydraulic graders built by the Commission were tried here, for the first time, with very satisfactory results. Although the crews are inexperienced and have yet much to learn as to the most efficacious way of doing the work, while the bank itself is unusually tough and difficult to grade, yet the cost per cubic yard is already less than 3 cents and will probably be brought below 2 cents as the men gain experience. Even now, the officer in charge reports a saving of fully $300 per day of 8 hours over hand grading, the machine with 12 men doing the work of 400 men with ordinary appliances.

The project for the improvement of Vicksburg harbor under which work is being prosecuted (see last annual report of the Commission), contemplates the excavation of a basin in front of the town, to be connected by an open cut with the deep water of the river. An allotment of $100,000 has been made by the Commission to begin this work, which has been duly advertised by the officer in charge. Proposals have recently been received, and it is expected that the work will soon begin. It is proposed for the first season to make the entrance through the west arm of the lake instead of along the lower city front, as ultimately contemplated, as this will enable partial relief to be more quickly given than could be done by a partial execution of the main object.

For details of work in third district, see report of Capt. W. L. Marshall, United States Engineers, Appendix L.

FOURTH DISTRICT.

(Warrenton to Head of Passes, 484 miles.)

This district embraces the improvement of Natchez harbor, and the rectification of Red and Atchafalaya Rivers, a lock at Bayou Plaquemine, and the improvement of New Orleans harbor.

NATCHEZ HARBOR.

Work has been carried on here for several years under the Engineer department, with special annual appropriations. The main object has been to arrest the caving of banks in Giles and Marengo Bends, which threatens damage to the harbor at Natchez. A resurvey of this locality has been ordered, pending the execution of which no allotment has been made. As soon as the survey is completed, and a plan and estimate prepared, the matter will receive attention.

RECTIFICATION OF RED AND ATCHAFALAYA RIVERS.

As a temporary relief to navigation, during the low-water season, the Commission recommended that the channel between Red River and the Mississippi be kept open by dredging and by stirring the bottom as in former years. This has been done with satisfactory results and no trouble has been reported. Neither the Red River nor the Mississippi have been very low, which has of course facilitated the work. A resurvey of the locality has been ordered preparatory to beginning the permanent work. No allotment recommended by the Commission in previous reports was needed, there being on hand a sufficient balance from former appropriations to carry on work contemplated during the present fiscal year.

LOCK AT BAYOU PLAQUEMINE.

This is a new work, and nothing can be decided on until the surveys ordered have been completed.

IMPROVEMENT OF NEW ORLEANS HARBOR.

A project for laying 10,000 linear feet of mattress revetment, 400 feet wide, to prevent further erosion in Carrollton Bend, has been approved by the Commission, and only awaits a favorable season for its execution. No allotment has been made, the balance available being sufficient for the work contemplated during the present fiscal year.

For details of work in fourth district, see report of Maj. Amos Stickney, United States Engineers, Appendix M.

The following plant is now on hand or in process of construction; its cost will be about $1,230,000:

Four hydraulic graders, 62 pile-drivers, 174 barges, 54 mattress and screen boats, 39 quarter boats, 2 derrick boats, 2 machine-shop boats, 6 steam tow-boats, 2 steam launches, 1 photograph boat, 139 skiffs.

For details of work done in the executive office of the Commission, construction department, see report of Captain C. B. Sears, United States Engineers, Appendix H.

FINANCIAL STATEMENT.

Appropriation for improving Mississippi River, act of August 2, 1882.

Amount appropriated	$4,123,000 00
Amount expended to December 1, 1882, including outstanding liabilities *(estimated)*, for steamboats, pile-drivers, barges, and other floating plant; for materials, tools, supplies, and labor for continuing and beginning work at Plum Point and Lake Providence, Memphis and New Madrid; for subsisting and quartering the labor employed, and for payments on contracts for construction and repair of levees	1,735,000 00
Balance, of which it is estimated that $950,000 will remain on hand at the close of the present fiscal year	2,388,000 00
	4,123,000 00

The estimate for next fiscal year for works of improvement, which was forwarded through the Chief of Engineers on the 3d of last October, is repeated below:

ESTIMATE OF FUNDS FOR WORKS OF IMPROVEMENT FOR NEXT FISCAL YEAR.

For works for contracting the channel and protecting caving banks on six reaches of the river, constituting a length of 184 miles, viz: New Madrid Reach, 40 miles long; the Plum Point Reach, 30 miles long; the Memphis Reach, 16 miles long; the Helena Reach, 30 miles long; the Choctaw Bend, 35 miles long, and the Lake Providence Reach, 30 miles long; for carrying on work at the harbors of Vicksburg, Natchez, and New Orleans, a lock at Bayou Plaquemine, the rectification of the Red and Atchafalaya Rivers, and for closing crevasses and outlets as auxiliary to works of channel improvement	$4,573,000

Itemized statement of expenditures from the appropriation for improving Mississippi River.

[Act of March 3, 1881.]

BALANCE SHEET.

Date.	By whom expended.	Plum Point Reach.	Lake Providence Reach.	General service.	On hand, all pledged.	Total to be accounted for.
1882. June 30	Paid by Captain Quinn and Lieutenant Knight	$477,569 66				
	Paid by Captain Sears	13,982 78				
	Paid by Lieutenant Marshall		$348,663 70			
	Paid by Captain Sears		15,792 42			
	Paid by Captain Sears			$107,760 58		
	Captain Sears				$20,464 22	
	Lieutenant Knight				12,424 90	
	Lieutenant Marshall				3,341 74	
	Total Plum Point Reach	491,552 44				$491,552 44
	Total Lake Providence Reach		364,456 12			364,456 12
	Total general service			107,760 58		107,760 58
	Total on hand, all pledged				36,230 86	36,230 86
	Amount to be accounted for					1,000,000 00

ITEMIZED STATEMENT.

PLUM POINT REACH.

Date.	Object of expenditure.	Paid by Captain Quinn and Lieutenant Knight.	Paid by Captain Sears.	Total.
1882.				
June 30	Office expenses: Services, furniture, and stationery, traveling expenses, freight and express charges, telegrams, mileage	$5,784 25	$117 80	$5,902 05
	Administration and inspection: Civil assistants, inspectors, overseers, and foremen	3,042 36	.....	3,042 36
	Labor on plant	68,028 89	.....	68,028 89
	Cost of plant: Machinery, hulls, and superstructure	226,136 04	.....	226,136 04
	Labor on construction	6,637 72	7,241 61	13,879 33
	Material: Wire, stone, piles, brush, &c	24,548 94	5,850 00	30,398 94
	Towage charter and steamer expenses	84,920 51	773 37	85,693 88
	Subsistence: Civil assistants, clerks, foremen and overseers, watchmen, and laborers	34,068 75	.....	34,068 75
	Surveys	6,201 47	.....	6,201 47
	Miscellaneous: Photograph outfit, care of property, quarters, medical attendance and supplies, repairs, salvage	18,200 73	.....	18,200 73
	Total	477,569 66	13,982 78	491,552 44

LAKE PROVIDENCE REACH.

Date.	Object of expenditure.	Paid by Lieutenant Marshall.	Paid by Captain Sears.	Total.
1882.				
June 30	Office expenses	$9,985 43	$52 04	$10,037 47
	Administration and inspection	4,603 31	.....	4,603 31
	Labor on plant	14,786 06	.....	14,786 06
	Cost of plant	195,168 53	9,367 00	204,535 53
	Labor on construction	10,676 40	.....	10,676 40
	Material: Wire, piles, stone, brush, &c	37,594 42	5,850 00	43,444 42
	Towage charter and steamer expenses	22,363 18	523 38	22,886 56
	Subsistence	8,187 43	.....	8,187 43
	Fuel	32,078 00	.....	32,078 00
	Surveys	8,918 93	.....	8,918 93
	Miscellaneous	4,302 01	.....	5,302 01
	Total	348,663 70	15,792 42	364,456 12

GENERAL SERVICE.

Office expenses	$546 94	
Labor on plant	1,087 43	
Cost of plant	13,126 86	
Towage and steamer expenses	6,567 40	
Material	2,192 41	
Fuel	83,241 29	
Miscellaneous	998 25	
	———	$107,760 58

BALANCES ON HAND, ALL PLEDGED.

Captain Sears	20,464 22	
Lieutenant Knight	12,424 90	
Lieutenant Marshall	3,341 74	
	———	36,230 86

DISBURSEMENTS.

Captain Quinn and Lieutenant Knight	477,569 66	
Lieutenant Marshall	348,663 70	
Captain Sears	137,535 78	
Unexpended balance, all pledged	36,230 86	
		1,000,000 00

RECAPITULATION.

Office expenses	16,486 46	
Administration and inspection	7,645 67	
Labor on plant	83,902 38	
Cost of plant	443,798 43	
Labor on construction	24,555 73	
Material	76,035 77	
Towage, steamer expenses, and charters	115,147 84	
Subsistence	42,256 18	
Fuel	115,319 29	
Surveys	15,120 40	
Miscellaneous	23,500 99	
Total	963,769 14	
Balance to meet liabilities	36,230 86	
		1,000,000 00
Estimated value of plant, fuel, material, and supplies on hand June 30, 1882		700,000 00

APPROXIMATE ESTIMATE OF COST OF PLANT.

[Itemized.]

Thirty-four pile-drivers, at $5,000 each	170,000 00
Four hydraulic graders, at $28,000 each	112,000 00
Eighty barges, at $1,500	120,000 00
Fifteen quarter-boats, at $3,500	52,500 00
Six mattress-boats, at $5,000	30,000 00
Forty-one skiffs, at $25	1,025 00
Steamer Mississippi	60,000 00
Steamer Itasca	9,500 00
Steam launches	6,000 00
Miscellaneous (rope, tools, photo-boat, &c.)	30,975 00
Total	592,000 00

FUEL.

Coal, including barges and boats stored in	115,000 00

MATERIAL.

Stone, including towage	15,000 00
Wire, including towage and inspection	13,000 00
Brush, piles, &c	40,000 00
Total	68,000 00

RECAPITULATION.

Plant	592,000 00
Fuel	115,000 00
Material	68,000 00
Total	775,000 00

CLINTON B. SEARS,
Captain Engineers, U. S. A., Executive Officer,
Construction Department, Mississippi River Commission.

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882.

[Act of Aug. 2, 1882.]

1. BY CLINTON B. SEARS, CAPTAIN ENGINEERS, U. S. A., EXECUTIVE OFFICER MISSISSIPPI RIVER COMMISSION.

LAKE PROVIDENCE REACH.—Capt. W. L. MARSHALL.

Third quarter, 1882.	Voucher number.	For what expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.														
June 15	7	For two mattress boats					$3,460 00						$3,460 00	
— —	8	For pay-roll								$1,551 71	175 00	$79 00	1,805 71	
— —	9	....do	$100 00							873 14	52 50	50 25	1,075 89	
— —	10	....do						$239 25		257 18	25 00		521 43	
July —	11	....do	9 50					7 50		149 00	3 60	3 50	173 10	
June —	12	....do	165 00							221 00	33 00		419 00	
12	26	For outfit and construction (hydraulic graders, Nos. 3 and 4)					2,818 21			1,258 00			4,076 21	
Apr. 21	28	For machinery and fuel (hydraulic graders, Nos. 3 and 4)				$351 15	66 40						417 55	
July 1	30	For four mattress boats					6,920 00						6,920 00	
1	31	For outfit (four hydraulic graders)				45 00	940 37			879 50			1,864 87	
Mar. 30	32	For outfit (pile drivers)					300 00						300 00	
June 8	34	For outfit (graders)					74 35						74 35	
13	35	....do					31 21						31 21	
8	36	For fuel (for graders)				89 39							89 39	
19	37	For painting (graders)					52 87			46 62			99 49	
May 25	38	For copperas			$10 95								10 95	
22	40	For outfit (quarter boat)					25 67	2 65					28 32	
27	41	For outfit (quarters for men)					42 50	2 75					45 25	
Mar. 11	43	For outfit (pile drivers)					151 77						151 77	
June 10	44	For outfit (pile drivers, &c.)					33 22	1 85					35 07	
1	45	For outfit (mattress boats and pile drivers)					22 50						22 50	
May 16	46	For outfit (quarters for men)					24 30	1 00					25 30	
25	47	For construction (mattress boats and pile drivers)					151 90	1 50					153 40	
27	48	For outfit (quarters for men)					19 25	1 00					20 25	

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882—Continued.

Third quarter, 1882.	Voucher number.	For what expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.														
May 11	49	For outfit (survey party)						$0 50	$18 75				$19 25	
13	50	For construction (pile drivers)					$59 73						59 73	
June 15	51	For machinery (pile drivers)					46 96						46 96	
May 23	52	For ice and coal				$297 84					$2,344 65		2,642 49	
June 10	57	For copper brands and oakum			$14 05								14 05	
May 15	59	For stationery (office use)		$12 05				1 00					13 05	
June 8	60	....do		7 20				1 00					8 20	
Apr. 28	62	For labor, towage, and repairs, barge No. 15						41 10		$88 70			129 80	
Aug. 28	64	For balance (on 4 pumping engines)					274 50						274 50	
18	65	For photo-lithographing		85 10									85 10	
Sept. 4	66	For towage (mattress boats)						200 00					200 00	
May 9	75	For towage (graders and barges, coal)						137 96					137 96	
9	Pt. 77	For pile drivers (expediting pile drivers, 8½ per cent. additional)					1,462 00						1,462 00	
Mar. 8	78	For outfit (graders)					129 00						129 00	
May 24	79	....do					300 53	2 50		66 00			369 03	
23	80	For outfit and construction (graders)				20 80		160 45		145 65			326 90	
Aug. 28	81	For outfit graders (steam chest)					31 70						31 70	
May 30	82	For iron (for pile drivers and barges)			121 17			14 34					135 51	
June 7	83	For subsistence stores (men)						8 90			203 27		212 17	
Feb. 3	84	For outfit (hydraulic graders)					165 20	21 15					186 35	
June 8	85	.... do					215 25						215 25	
Feb. 10	86	For construction and repairs (lumber and shingles)					1,870 80	446 21					2,317 01	
June 10	87	For outfit graders (ship chandlery)					1,135 67						1,135 67	
May 30	88	For outfit (pile drivers)					1,457 74	47 08					1,504 82	
13	93	....do					1,213 49						1,213 49	
		Totals	$274 50	104 35	146 17	804 18	23,497 09	1,339 69	18 75	5,536 50	2,837 02	$132 75	34,691 00	$34,691 00

PLUM POINT REACH.—Capt. J. C. D. KNIGHT.

July 19	14	For traveling expenses (J. W. Shea, account Itasca)					3 20						3 20	
20	15	For balance due on Itasca					3,346 69						3,346 69	
May —	18	For pay-roll (construction Itasca)	1,052 00				125 00						125 00	
—	24	For pay-roll							90 00	3,343 39	185 00	88 00	4,758 39	
June 15	42	For outfit Itasca (steam capstan)					525 00						525 00	
Apr. 29	53	For ice and barge					750 00				2,130 00		2,880 00	
	72	For pay-roll (construction Itasca)					125 00						125 00	
June 30	74	For outfit and repairs (pile drivers)					107 50	2 00				4 50	114 00	
May 9	Pt. 77	For pile drivers (expediting pile drivers, 8½ per cent. additional)					1,462 00						1,462 00	
	Pt. 96	For construction steamer Itasca (material and labor)						17 72					17 72	
Sept. 26	106	For steamer Pete Kirns					11,740 00						11,740 00	
Aug. 29	107	For ice									1,177 00		1,177 00	
Sept. 12	108	For transportation (cartage account steamer Itasca)						1 50					1 50	
	Pt. 109	For inspector (construction steamer Itasca)	62 50										62 50	
		Total	1,114 50				18,184 39	21 22	90 00	3,343 39	3,492 00	92 50	26,338 00	26,338 00

GENERAL SERVICE.

	Coal Fleet; Cairo, Ill.												
21	For stores and supplies									8 37	4 75	13 12	
30	For pay-roll										587 25	587 25	
39	For supplies										7 50	7 50	
68	....do										3 20	3 20	
69	For towage (tug Ariadne)						12 00					12 00	
70	For ice									5 88		5 88	
71	For pay-roll										740 25	740 25	
118	For ice									2 47		2 47	
	Totals						12 00			16 72	1,342 95	1,371 67	1,371 67
	U. S. Steamer Etheridge.												
6	For charter, steamer Emma Etheridge						930 00					930 00	
Pt. 18	For pay-roll						80, 00					80 00	
Pt. 23	For ice (watchman)									1 60		1 60	
33	For repairs (labor and material)						13 00					13 00	
55	For outfit (medicine chest)						37 97					37 97	
56	For outfit (stores and supplies)						82 56			196 96		279 52	
61	For outfit (mosquito bars)						20 70					20 70	
76	For fuel (labor on 1,781 boxes coal)						44 52					44 52	
90	For repairs (cleaning boilers)						2 50					2 50	
91	For pay-roll						189 51			25 00	9 33	223 84	

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882—Continued.

Third quarter, 1882.	Voucher number.	For what expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.														
Sept. 12	94	For outfit						$15 00					$15 00	
	95	....do						4 90					4 90	
	Pt. 96	For repairs (material and labor)						2 85					2 85	
	97	For outfit						75 13					75 13	
	99	For outfit and subsistence						72 32			$152 89		225 21	
	101	For fuel (labor on 1,125 boxes coal)						28 13					28 13	
	102	For towboat (Emma Etheridge)						19, 500 00					19, 500 00	
	112	For pay-roll						1, 058 83			129 99	$40 00	1, 228 82	
	113	For subsistence									10 00		10 00	
	114	....do									13 60		13 60	
	115	For repairs (cleaning boilers)						3 00					3 00	
	116	For fuel (labor on 200 boxes coal)						5 00					5 00	
	117	For subsistence and supplies						27 95			161 25		189 20	
		Totals						22, 193 87			691 29	49 33	22, 934 49	$22, 934 49
		U. S. Steamer Mississippi.												
	2	For services (first engineer)						125 00					125 00	
	3	For traveling expenses (J. W. Shea)	$5 00										5 00	
	Pt. 18	For pay-roll						239 17					239 17	
	Pt. 23	For ice (watchman)									1 60		1 60	
	29	For outfit (labor and material)						4, 361 19					4, 361 19	
	67	For ice (watchman)									3 00		3 00	
	72	For pay-roll (watchman)										68 00	68 00	
	73	For traveling expenses (John M. Sears)	4 40										4 40	
	89	For pay-roll						70 00				44 00	114 00	
	92	For outfit						13 20					13 20	
	98	....do						30 50					30 50	
	99	....do						17 63					17 63	
	111	Pay-roll						63 34			8 00	6 00	77 34	
		Totals	9 40					4, 920 03			12 60	118 00	5, 060 03	5, 060 03

Third quarter, 1882.	Voucher number.	For what expended.	No. 1.—Pay.	No. 2.—Furniture and outfit.	No. 3.—Stationery and supplies.	No. 4.—Transportation and traveling expenses.	No. 5.—Ice and water.	No. 6.—Rent and repairs.	No. 7.—Gas and fuel.	No. 8.—Telegrams.	No. 9.—Mileage.	No. 10.—Fuel for Captain Sears.	No. 11.—Total.	No. 12.—Total.
		Executive office Mississippi River Commission, Capt. C. B. Sears.												
1882.														
Sept. 12	1	For mileage (Capt. C. B. Sears)									$23 68		$23 68	
	4	For traveling expenses (James Good)				$18 50							18 50	
	5	For rent of quarters (Capt. C. B. Sears)						$36 00					36 00	
	13	For transportation (car tickets)				4 87							4 87	
	16	For fuel (Capt. C. B. Sears)										$4 72	4 72	
	17	For transportation (car tickets)				10 00							10 00	
	18	For pay-roll	$225 00			200 00							425 00	
	19	For ice					$8 28						8 28	
	22	For mileage (Capt. C. B. Sears)									23 68		23 68	
	25	....do									170 56		170 56	
	27	For fuel (Capt. C. B. Sears)										4 72	4 72	
	54	For traveling expenses (James Good)				24 00							24 00	
	58	For stationery			$76 50								76 50	
	63	For mileage (Capt. C. B. Sears)									52 64		52 64	
	72	For pay-roll	225 00			200 00							425 00	
	100	For paper			15 00								15 00	
	103	For fuel (Capt. C. B. Sears)										23 60	23 60	
	104	For transportation (car tickets)				10 00							10 00	
	105	For mileage (Capt. C. B. Sears)									85 76		85 76	
	109	For pay-roll	269 33			200 00							469 33	
	110	Telegrams								$25 66			25 66	
		Totals	719 33		91 50	667 37	8 28	36 00		25 66	356 32	33 04	1,937 50	$1,937 50

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882—Continued.

PLUM POINT REACH.—Capt. J. G. D. KNIGHT.

October and November of fourth quarter, 1882.	Voucher number.	For what expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.														
Oct. 3	7	For one barge					$1,000 00						$1,000 00	
Sept. 30	11	For inspection	$330 00										330 00	
Oct. 3	14	For material (miscellaneous supplies)			$188 45			$7 55					196 00	
3	15	For material (miscellaneous supplies)			2,896 36			26 40					2,922 76	
4	16	For machinery					445 00	4 70					449 70	
19	17	For material (miscellaneous supplies)			229 20			3 20					232 40	
3	18	For material (miscellaneous supplies)			33 53			1 00					34 53	
11	21	....do			265 25			10 95					276 20	
11	29	....do			48 50			2 00					50 50	
11	31	For subsistence						9 00			$356 25		365 25	
11	36	For towage and repairs						160 70					160 70	
6	37	For towage (barge)						25 00					25 00	
12	38	For towage (two barges)						95 00					95 00	
9	39	For plant (twenty skiffs)					330 00						330 00	
17	40	For subsistence						6 80			44 03		50 83	
13	41	For material (miscellaneous supplies)			36 90			13 05			135 60		185 55	
Sept. 30	43	For outfit (steamer Itasca)					48 00						48 00	
Oct. 14	56	For material (miscellaneous supplies)			53 10			10 93			134 85		198 88	
18	59	....do			33 75			225					36 00	
18	60	For material (rope)			909 13			17 96					927 03	
21	62	For plant (barge 131 for quarter boat)					1,000 00						1,000 00	
17	64	For subsistence						13 75			238 77		252 52	
23	67	....do									43 11		43 11	
16	68	For care public property (watchman)										$20 00	20 00	
19	71	For material (miscellaneous supplies)			235 23								235 23	
11	73	For subsistence						1 00			40 50		41 50	
25	74	For material (miscellaneous supplies)			6 00								6 00	
11	75	For repairs (barge 131)						148 95					148 95	
10	77	For towage (barge 131)						5 00					5 00	
27	78	For plant (one-decked barge)					600 00						600 00	
26	80	For material (miscellaneous supplies)			94 58			1 00					95 58	
26	81	....do			903 00			50 65					953 65	

Oct. 27	82	....do			337 26			6 00						372 27	
26	83	....do			21 11			1 00						25 60	
30	87	For subsistence						10 50			290 00			1 38	
30	88	....do						4 20			17 40			10 50	
30	92	....do						22 05			525 45			50 05	
30	95	For towage (coal fleet)						25 00						15 00	
30	98	For material (miscellaneous supplies)			3 60			1 00						13 47	
30	101	For outfit (quarter boats)					350 87	21 40						31 65	
26	102	For subsistence (medical supplies)						1 00			24 60			218 75	
Nov. 1	107	For repairs (steamer Itasca)						1 38						24 70	
Sept. 12	112	For outfit (awnings for steamers)						10 50						35 20	
Nov. 2	121	For subsistence						7 35			42 70			60 66	
6	124	For labor								$15 00				1,315 00	
Oct. 29	128	For subsistence						1 00			12 47			17 70	
Nov. 8	131	For material (miscellaneous supplies)			30 65			1 00						98 09	
9	133	For subsistence									218 75			18 00	
Oct. 24	136	....do						1 20			23 50			24 70	
Nov. 8	137	For material (miscellaneous supplies)			29 25			1 70			4 25			35 20	
9	140	....do			58 91			1 75						60 66	
8	141	For material (lumber)			1,070 00			245 00						1,315 00	
9	142	For subsistence and material			1 20			1 00			15 50			17 70	
10	143	....do						5 60			92 49			98 09	
9	148	For stationery (forms)		$18 00										18 00	
11	150	For subsistence						4 80			42 56			47 36	
20	151	....do						5 60			42 06			47 66	
13	157	For material (miscellaneous supplies)			180 00									180 00	
15	163	....do			13 13									13 13	
15	169	....do			249 90									249 90	
15	170	....do			12 15			1 00						13 15	
15	177	For outfit (quarter boats)					300 00							300 00	
21	187	For stationery		4 00										4 00	
28		Total	330 00	22 00	7,940 14		4,073 87	997 81		15 00	2,344 84	20 00	15,743 66	$15,743 66	

LAKE PROVIDENCE REACH.—Capt. W. L. MARSHALL.

1882.															
Oct. 7	22	For subsistence						63 25			471 50			534 75	
6	23	....do						8 65			265 91			274 56	
7	24	For subsistence and material (miscellaneous supplies)			112 68			13 25			160 19			286 12	
6	25	....do			139 78			37 55			669 66			846 99	
6	26	....do			1 20			1 90			71 65			74 75	
9	27	For material (rope)			2,742 75			82 28						2,825 03	
7	28	For subsistence and material (miscellaneous supplies)			46 38			10 75			35 00			92 13	
7	30	For subsistence						18 00			246 00			264 00	
4	32	....do						10 00			544 92			554 92	
12	35	For plant (two quarter boats)					4,435 00							4,435 00	

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882—Continued.

October to November of fourth quarter, 1882.	Voucher number.	For what expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.														
Oct. 12	Pt. 38	For towage (one pile-driver hull and two quarter boats)	.....	.....	.....	.....	.....	$225 00	.....	.....	.....	.....	$225 00	.....
27	78	For plant (one-decked barge)	.....	.....	.....	.....	$600 00	.....	.....	.....	.....	.....	600 00	.....
31	86	For inspection	$18 32	.....	.....	.....	.....	.....	.....	.....	.....	.....	18 32	.....
19	91	.....do	8 60	.....	.....	.....	.....	.....	.....	.....	.....	.....	8 60	.....
Nov. 3	111	For plant (two barges)	.....	.....	.....	.....	6, 000 00	.....	.....	.....	.....	.....	6, 000 00	.....
9	130	For plant (four mattress boats)	.....	.....	.....	.....	24, 000 00	.....	.....	.....	.....	.....	24, 000 00	.....
9	132	For subsistence	.....	.....	.....	.....	.....	18 95	.....	.....	$488 38	.....	507 33	.....
9	134	.....do	.....	.....	.....	.....	.....	2 59	.....	.....	115 17	.....	117 67	.....
8	135	For subsistence and material (miscellaneous supplies)	.....	.....	$9 48	.....	.....	14 55	.....	.....	165 20	.....	189 23	.....
8	138	.....do	.....	.....	20 57	.....	.....	4 35	.....	.....	2 40	.....	27 32	.....
9	139	For subsistence	.....	.....	.....	.....	.....	19 50	.....	.....	351 00	.....	370 50	.....
9	144	For subsistence and material (miscellaneous supplies)	.....	.....	88 75	.....	.....	23 30	.....	.....	271 27	.....	383 32	.....
8	154	For subsistence	.....	.....	.....	.....	.....	7 60	.....	.....	141 28	.....	148 88	.....
8	159	.....do	.....	.....	.....	.....	.....	6 87	.....	.....	130 28	.....	137 15	.....
28	187	For stationery	.....	$4 00	.....	.....	.....	.....	.....	.....	.....	.....	4 00	.....
Oct. 17	Pt. 54	For material (rope)	.....	.....	10 39	.....	.....	.....	.....	.....	.....	.....	10 39	.....
		Total	26 92	4 00	3, 171 98	.....	35, 035 00	568 25	.....	.....	4, 129 81	.....	42, 935 96	$42, 935 96

MEMPHIS REACH.—Capt. A. M. MILLER.

Oct. 17	Pt. 54	For material (rope)	.....	.....	20 78	.....	.....	.....	.....	.....	.....	.....	20 78	.....
14	Pt. 57	For traveling expenses (Temple)	32 10	.....	.....	.....	.....	.....	.....	.....	.....	.....	32 10	.....
31	84	For inspection	29 17	.....	.....	.....	.....	.....	.....	.....	.....	.....	29 17	.....
31	85	.....do	58 33	.....	.....	.....	.....	.....	.....	.....	.....	.....	58 33	.....
31	86	.....do	9 17	.....	.....	.....	.....	.....	.....	.....	.....	.....	9 17	.....
28	109	For watchman, pumping, and repair	.....	.....	.....	.....	.....	.....	.....	.....	.....	43 40	43 40	.....
Nov. 11	148	For stationery	.....	12 00	.....	.....	.....	.....	.....	.....	.....	.....	12 00	.....
Oct. 15	166	For towage (one barge)	.....	.....	.....	.....	.....	20 00	.....	.....	.....	.....	20 00	.....

Nov. 18	Pt. 172	For traveling expenses (Temple)	40 00										40 00	
30	Pt. 180	For inspection (Temple)	62 50										62 50	
Nov. 15	184	For plant (one machine-shop boat)				3,380 00							3,380 00	
21	Pt. 200	For traveling expenses (James Good)	41 00										41 00	
25	Pt. 201	....do	31 00										31 00	
		Total	303 27	12 00	20 78	3,380 00	20 00					43 40	3,779 45	$3,779 45

NEW MADRID REACH.—Capt. J. G. D. KNIGHT.

1882.														
Oct. 6	34	For plant (hull & cargo-box for quarter-boat)				2,200 00							2,200 00	
17	Pt. 54	For material (rope)			72 68								72 68	
25	74	For material (burning brands)			6 00								6 00	
31	85	For inspection	29 17										29 17	
31	86	....do	64 18										64 18	
11	148	For stationery		18 00									18 00	
15	166	For towage					20 00						20 00	
5	Pt. 174	For traveling expenses (Temple)	16 00										16 00	
15	184	For plant (machine-shop boat)				3,380 00							3,380 00	
Nov. 30	Pt. 180	For inspection (Temple)	62 50										62 50	
		Total	171 85	18 00	78 68	5,580 00	20 00						5,868 53	5,868 53

NEW ORLEANS.—Maj. AMOS STICKNEY.

1882.														
Nov. 11	148	For stationery (forms)		12 00									12 00	
17	193	For transportation					80						80	
		Total		12 00			80						12 80	$12 80

GENERAL SERVICE.

1882.		*U. S. steamer Mississippi.*												
Sept. 9	4	For outfit					44 20						44 20	
13	5	For material (miscellaneous supplies)			2 90								2 90	
May 25	6	For material and labor (construction outfit)			34 63				14 00				48 63	
Sept. 26	8	For material (lumber for repairs)			7 57								7 57	
6	9	....do			3 04								3 04	
Oct. 11	20	For outfit					152 00						52 00	
7	33	....do					18 98						18 98	
7	46	For material (oil and paint for repairs)			40 50								40 50	
6	47	For outfit					2 00						2 00	
18	55	For outfit (electric lights)					1,070 00						1,070 00	
24	76	For material (oils and paints for machinery and repairs)			78 61				2 50				81 11	

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882—Continued.

October and November of fourth quarter, 1882.	Voucher number.	For what expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.														
Oct. —	89	For October pay-roll						$450 67					$450 67	
30	94	For outfit						1 80					1 80	
19	104	For material and labor (outfit)			$38 53					$10 00			48 53	
31	113	For outfit						49 84					49 84	
Sept. 12	122	Stationery (office)		$6 75									6 75	
31	129	For towage						25 00					25 00	
Nov. 7	158	For outfit (steam fittings)						9 77					9 77	
Oct. 20	160	For labor (cleaning hold)								8 00			8 00	
Nov. 15	161	For outfit (Frisbie valves)						450 00					450 00	
15	162	For outfit (machinery)						935 35					935 35	
8	164	For material (lumber)			12 80								12 80	
3	165	For outfit						4 37					4 37	
Oct. 12	168	For material and labor (outfit)			9 10					6 00			15 10	
June 1	186	For fuel				$94 17							94 17	
Nov. 16	188	For material (repairs of outfit)			3 60								3 60	
Oct. 30	190	For outfit (flag)						8 50					8 50	
30	199	For November pay-roll						251 16					251 16	
Nov. 24	219	For outfit						38 40					38 40	
		Total		6 75	231 28	94 17		3,512 04		40 50			3,884 74	$3,884 74
		U. S. steamer Etheridge.												
Sept. 28	19	For labor (coaling)								33 50			33 50	
Oct. 11	20	For outfit (barometer, compass, &c.)						63 00					63 00	
—	45	For October pay-roll						589 33			$80 67	$24 00	694 00	
18	49	For repairs			1 00					17 25			18 25	
9	50	For subsistence									20 80		20 80	
6	51	....do									18 50		18 50	
7	52	For outfit (transportation)						3 70					3 70	
14	53	For material and subsistence			2 86						35 25		38 11	
23	66	For subsistence									22 03		22 03	
23	72	....do									37 64		37 64	
29	93	....do									13 95		13 95	
15	96	For labor (coaling)								13 13			13 13	

23	97	....do								27 13			27 13		
23	99	For material, subsistence, &c			25 75			58 03		24 75	144 64		253 17		
23	106	For material and labor (repairs)			37 15					27 00			64 15		
Sept. 12	122	For stationery		14 00									14 00		
—	125	For October pay-roll						377 17			43 50		420 67		
Nov. 7	126	For subsistence									23 50		23 50		
15	171	For labor (coaling)								19 13			19 13		
15	172	For subsistence									44 01		44 01		
21	175	....do									67 05		67 05		
21	178	For material and subsistence			1 50						108 24		109 74		
Oct. 13	179	For services						15 17					15 17		
Nov. 21	189	For material (lumber)			11 70								11 70		
6	224	For subsistence									5 46		5 46		
22	225	For labor (coaling)								51 50			51 50		
		Totals		14 00	79 96			1,106 40		213 39	665 24	24 00	2,102 99	$2,102 99	
		U. S. coal fleet (Cairo, Ill.)													
	1	For supplies			6 60								6 60		
Sept. 2	2	For pumping (tug Laurel)										20 00	20 00		
28	3	For towage (tug Ariadne)						5 00					5 00		
30	12	For September pay-roll										677 50	677 50		
—	108	For subsistence									3 75		3 75		
Oct. 31	110	For pumping (Reindeer)										205 00	205 00		
Nov. 1	123	For supplies			15 96								15 96		
Oct. 24	167	For October pay-roll										549 58	549 58		
—	206	For November pay-roll										494 90	494 90		
		Totals			22 56			5 00			3 75	1,946 98	1,978 29	1,978 29	

Itemized statement of expenditures for improving the Mississippi River from July 1 to December 1, 1882—Continued..

October and November of fourth quarter.	Voucher number.	For what expended.	No. 1.—Pay.	No. 2.—Furniture and outfit.	No. 3.—Stationery and supplies.	No. 4.—Transportation and traveling expenses.	No. 5.—Ice and water.	No. 6.—Rent and repairs.	No. 7.—Gas and fuel.	No. 8.—Telegrams.	No. 9.—Mileage.	No. 10.—Fuel for Captain Sears.	No. 11.—Total.	No. 12.—Total.
1882.		*Executive office, Mississippi River Commission, Capt. C. B. Sears.*												
Oct. 4	10	For stationery and supplies (draughtsman's)			$23 10								$23 10	
4	13	For traveling expenses (Capt. James Good)				$158 05							158 05	
14	42	For mileage (Capt. C. B. Sears)									$108 56		108 56	
15	44	For traveling expenses (Capt. James Good)				84 25							84 25	
16	58	For traveling expenses (Garry Spencer)				4 00							4 00	
21	61	For repairs (moving safe)						$25 00					25 00	
23	63	For transportation (car tickets)				10 00							10 00	
21	65	For repairs (moving office furniture)						7 00					7 00	
26	69	For fuel (Capt. C. B. Sears)										$23 60	23 60	
23	70	For stationery and supplies (draughtsman's)			13 90								13 90	
24	79	For stationery and supplies (rubber stamps)			6 00								6 00	
—	90	For October pay-roll	$506 00			200 00		13 00					719 00	
31	100	For water (three months)					$3 75						3 75	
31	105	For sign (office)			3 00								3 00	
Nov. 13	114	For stationery (tri-monthly reports)			10 50								10 50	
Oct. 30	115	For transportation and traveling expenses (James Good)				26 50							26 50	
27	116	For supplies			17 22								17 22	
26	117	For furniture		$41 35									41 35	
25	118	For outfit		6 00									6 00	
Nov. 1	119	For gas							$2 50				2 50	
Oct. 31	120	For outfit		19 55									19 55	
Nov. 1	122	For stationery			95 60								95 60	
1	127	For rent						22 00					22 00	
1	145	For furniture and outfit (gas fixtures)		30 00									30 00	
10	146	For furniture and outfit (lamps)		11 00									11 00	
10	147	For furniture and outfit (speaking-tube)		8 75									8 75	
1	152	For fuel (office use)							36 75				36 75	
14	153	For fuel (Capt. C. B. Sears)										23 60	23 60	
14	155	For transportation (car tickets)				10 00							10 00	
14	156	For traveling expenses (Capt. James Good)				23 50							23 50	
18	176	For paper (blanks, transmittals, and receipts)			8 00								8 00	

25	191	For traveling expenses (Garry Spencer)				24 00							24 00	
—	192	For November pay-roll	576 00			200 00		13 50					789 50	
16	194	For transportation (books and papers)				1 00							1 00	
15	195	For transportation (office outfit)				75							75	
28	197	For mileage (Capt. C. B Sears)									57 84		57 84	
		Totals	1,082 00	116 65	177 32	742 05	3 75	80 50	39 25		166 40	47 20	2,455 12	$2,455 12

RECAPITULATION.

Time.	Where expended.	No. 1.—Administration and inspection.	No. 2.—Office expenses.	No. 3.—Material and miscellaneous supplies.	No. 4.—Fuel.	No. 5.—Cost of plant.	No. 6.—Transportation and steamer expenses.	No. 7.—Surveys.	No. 8.—Labor on plant and construction.	No. 9.—Subsistence.	No. 10.—Care of public property.	No. 11.—Totals.	No. 12.—Totals.
1882.	Third, and October and November of fourth quarter, 1882:												
REACHES.													
Third quarter	Lake Providence Reach	$274 50	$104 35	$146 17	$804 18	$23,497 09	$1,339 69	$18 75	$5,536 50	$2,837 02	$132 75	$34,691 00	
Fourth quarter, October and November.	do	26 92	4 00	3,171 98		35,035 00	568 25			4,129 81		42,935 96	
Third quarter	Plum Point Reach	1,114 50				18,184 39	21 22	90 00	3,343 39	3,492 00	92 50	26,338 00	
Fourth quarter, October and November.	do	330 00	22 00	7,940 14		4,073 87	997 81		15 00	2,344 84	20 00	15,743 66	
Fourth quarter, October and November.	New Madrid Reach	171 85	18 00	78 68		5,580 00	20 00					5,868 53	
Fourth quarter, October and November.	Memphis Reach	303 27	12 00	20 78		3,380 00	20 00				43 40	3,779 45	
Fourth quarter, October and November.	New Orleans		12 00				80					12 80	
GENERAL SERVICE.													
Third quarter	Coal fleet						12 00			16 72	1,342 95	1,371 67	
Fourth quarter, October and November.	do			22 56			5 00			3 75	1,946 98	1,978 29	
Third quarter	Mississippi	9 40					4,920 03			12 60	118 00	5,060 03	
Fourth quarter, October and November.	do		6 75	231 28	94 17		3,512 04		40 50			3,884 74	
Third quarter	Etheridge						22,193 87			691 29	49 33	22,934 49	
Fourth quarter, October and November.	do		14 00	79 96			1,106 40		213 39	665 24	24 00	2,102 99	
Total		2,230 44	193 10	11,691 55	898 35	89,750 35	33,717 11	108 75	9,118 78	14,193 27	3,769 91	166,701 61	$166,701 61

RECAPITULATION—Continued,

Time.	Where expended.	No. 1.—Pay.	No. 2.—Furniture and outfit.	No. 3.—Stationery and supplies.	No. 4.—Transportation and traveling expenses.	No. 5.—Ice and water.	No. 6.—Rent and repairs.	No. 7.—Gas and fuel.	No. 8.—Telegrams.	No. 9.—Mileage.	No. 10.—Fuel for Captain Sears.	No. 11.—Total.	No. 12.—Total.
1882.	Office expenditures third quarter, and October and November of fourth quarter:												
Third quarter	Office	$719 33	.....	$91 50	$667 37	$8 28	$36 00	.....	$25 66	$356 32	$33 04	.....	$1,937 50
Fourth quarter, October and November.	.....do	1,082 00	$116 65	177 32	742 05	3 75	80 50	$39 25	.....	166 40	47 20	.....	2,455 12
Totals		1,801 33	116 65	268 82	1,409 42	12 03	116 50	39 25	25 66	522 72	80 24	$4,392 62	4,392 62

NOVEMBER 30, 1882.

CLINTON B. SEARS,
Captain Engineers, U. S. A., Executive Officer Construction Department, Mississippi River Commission.

2.—By Capt. J. G. D. Knight, Corps of Engineers, in Charge of First District, Mississippi River.

[Taken from Appendix J.]

Amount allotted for improvement of (Plum Point) Reach		$700,000 00
Expended to December 1, 1882—		
Administration	$3,043 23	
Office expense	1,136 68	
Construction of plan	15,518 58	
Labor on plant	23,551 08	
Labor on construction	25,946 76	
Materials for construction	12,418 67	
Subsistence	16,685 79	
Care of property	7,485 62	
Quarter	6,074 26	
Steamers, towage, &c	6,633 12	
Surveys	871 05	
Medicines	111 21	
Mileage and traveling expenses	68 01	
		119,544 06
Balance, from which expenditures by the executive officer should be deducted		580,455 94
		700,000 00

3.—By Capt. A. M. Miller, Corps of Engineers, in Charge of Second District, Mississippi River.

[Taken from Appendix K.]

Object of expenditure.	Expended to December 1, 1882, from allotment for—			
	Memphis Reach and harbor.	Construction and repair of levees—Yazoo front.	Survey of Helena Reach.	Survey of the Saint Francis front.
Assistant engineers	$1,010 00	$550 00	$300 00	$330 00
Clerk	125 00	.....	.....	.....
Stationery	14 14	14 90	.....	.....
Materials	1,138 13	.....	.....	.....
Supplies	75 86	.....	139 05	24 85
Outfit	181 05	2 10	574 92	617 27
Hire of tug and barges	1,319 00	.....	.....	.....
Labor	7,518 00	211 00	1,079 99	570 83
Subsistence	2,334 50	.....	235 96	282 46
Repairs	145 90	.....	6 00	.....
Traveling expenses	134 94	75 00	.....	79 95
Telegrams	.....	50 41	.....	.....
Advertising and printing	.....	220 06	.....	.....
Work on Lake Charles break, on contract	.....	.....	.....	.....
Towage	.....	4,147 02	.....	.....
Hire of team	.....	.....	.....	20 00
Transportation	.....	.....	.....	100 00
	.....	.....	.....	60 10
Totals	13,997 21	5,270 49	2,335 92	2,085 46
Balances	311,002 79	75,679 51	5,664 08	1,914 54
Allotments	325,000 00	80,950 00	8,000 00	4,000 00

4.—By Capt. W. L. Marshall, Corps of Engineers, in Charge of Third District, Mississippi River.

[Taken from Appendix L.]

Object of expenditure.	Expended from allotment for—			
	Lake Providence Reach.	Harbor of Vicksburg.	Levees.	Survey of Choctaw Reach.
Plant and tools	$23,068 48	$4,293 63	.....	.....
Coal and piles	3,873 15	.....	.....	.....
Services	46,061 80	15,062 46	$4,127 05	$499 17
Tow-boat service	5,492 03	1,915 25	.....	.....
Subsistence	6,968 33	5,992 73	177 93	6 25
Miscellaneous	1,611 44	420 88	749 81	99 30
Stone and coal	.....	327 35	.....	.....
Contractor's estimates	.....	.....	57,323 55	.....
Instruments	.....	.....	1,319 35	.....
Totals	87,075 23	28,012 30	63,697 69	604 72
Balances	562,924 77	47,757 83	619,192 31	3,395 28
Allotments	650,000 00	*75,770 13	682,890 00	4,000 00

* Includes a balance from a previous appropriation of $25,770.13.

5.—By Maj. Amos Stickney, Corps of Engineers, in charge of Fourth District, Mississippi River.

IMPROVING HARBOR AT NEW ORLEANS, LA.

			1882.		
Pay-roll	Service	$40 00	July 1	On hand, assistant treasurer, New Orleans, La	$3,267 91
Do	do	340 00	Dec. 1	Disbursements	1,212 12
Do	do	183 50			
H. S. Douglas	Drayage	1 50			
Alleyn	Telegrams	4 47			
Pay-roll	Service	274 50			
Amos Stickney	Mileage	36 32			
O'Donnell	Rent	75 00			
Do	Stationery	8 87			
Seebold	Tracing-cloth and drawing-paper	26 46			
Pay-roll	Service	40 00			
Do	do	16 50			
Do	do	165 00			
Total		1,212 12	Dec. 1	Balance on hand	2,055 79

IMPROVING MISSISSIPPI RIVER AT NATCHEZ, MISS., AND VIDALIA, LA.

Pay-roll	Service	$345 00	Sept. 9	Transfer from Captain Miller	$7,529 09
Moses	Material	4 20	Dec. 1	Disbursements	550 08
Schwartz	do	11 60			
Rumble & Wensel	do	37 00			
Buckley & Co	Stationery	6 95			
Pay-roll	Service	11 67			
Do	do	133 66			
Total		550 08	Dec. 1	Balance on hand	6,979 01

5.—By Maj. Amos Stickney, Corps of Engineers, in charge of Fourth District, Mississippi River—Continued.

IMPROVING MOUTH OF RED RIVER, LOUISIANA.

Fagan	Hire of vessels	$5,850 00	Sept. 30	Transfer from Captain Miller	$8,153 94
Pay-roll	Service	1,090 00	Dec. 1	Disbursements	15,277 87
Mortimer	Material and provisions	8 03			
Wescoat	Transportation	4 40			
Do	do	55			
O'Donnell	Rent of office	75 00			
Pay-roll	Service	1,095 00			
Fagan	Hire of vessels	6,045 00			
Do	Board of Engineer employés	165 00			
Wilson & Fagan	Provisions	184 71			
Mortimer & Ferguson	Material and provisions	7 25			
Fagan	Board of Engineer employés	170 50			
Blanks	Transportation	75			
Rivers	Quarters	48 00			
Woodward & Wight	Material and provisions	308 68			
Pay-roll	Service	225 00			
		15,277 87	Dec. 1	Balance due from appropriation	7,123 93

IMPROVING MISSISSIPPI RIVER (NO LIMIT).

Solari	Provisions, &c	$68 09	Oct. 13	Deposited with assistant treasurer, New Orleans, La	$50,000 00
Pay-roll	Service	374 25			
Henry	Drayage	1 00			
Warden	Skiff	15 00			
Pay-roll	Service	84 67			
Walton	Provisions, &c	29 90			
Cooper	Traveling expenses	54 00			
Irvine	Provisions	10 60			
Mortimer	Material, skiff, &c	52 74			
Lyons	Medicine	5 50			
Baldwin & Co	Material	12 17			
Lhote & Co	1 by 3 pine	11 20			
Irvine	Ice	6 00			
Turner	Drayage	75			
Cassidy & Miller	Material	97 10			
Woods	Transportation	145 00			
Alleyn	Telegrams	9 39			
Solari	Provisions, &c	153 08			
Amos Stickney	Mileage	63 04			
Do	do	63 04			
Do	do	63 04			
O'Donnell	Stationery	39 50			
Do	do	4 50			
Seelold	Profile paper	13 50			

Richardson	Traveling expenses	102 00				
Janney	Provisions, transportation	49 48				
Conery & Son	Transportation	92 00				
Vidon	Skiff	15 00				
Holmes	Material	2 30				
Rice, Born & Co	do	63 09				
Solari	Provisions, &c	171 01				
Alleyn	Telegrams	11 37				
Woods	Transportation	7 00				
Conery & Son	do	15 00				
Dunn & Bro	Copy book	2 50				
Pay-roll	Service	727 41				
Do	do	233 67				
Do	do	559 67				
McCoy	Skiff	18 00				
Greany	Meat, oil	3 00				
Clairborne	Transportation	8 00				
Bell	Traveling expenses	10 50				
Pay-roll	Service	344 67				
Do	do	188 67				
Do	do	191 34				
Kellogg	Material and provisions	1 35				
Cohn & Co	Oil, yeast powders	1 00				
Miller	Fresh beef	2 34				
Turner	Transportation	10 00				
Berry	Provisions, &c	5 77				
Douglas, H. S.	Traveling expenses	18 25				
Do	do	49 50				
Do	Transportation	20 00				
Douglas, A	Traveling expenses	8 50				
Weldon	do	8 50				
Watkins	Traveling expenses	8 50				
Hoffman	do	36 10				
Dolan	Service	6 67				
Claudel	Material and service	19 00				
Seebold	Tracing-paper	6 00				
Hunter	Provisions	4 05				
Cohn	Material, provisions, &c	8 15				
Watkins	Traveling expenses	3 50				
Thompson	do	25 85				
Do	Provisions, service, &c	26 30				
Ascher & Co	Provisions	13 25				
Queen & Co	Cross-section paper	31 50				
Buff & Berger	Level-rods	56 20				
Pay-roll	Service	470 00	Dec. 1	Disbursements		5,033 02
		5,033 02	Dec. 1	Balance on hand		44,966 98

AMOS STICKNEY,
Major of Engineers, U. S. A.

OUTLETS AND LEVEES.

The Commission, in its earlier reports, agreed in recommending the confinement and concentration of discharge, by restraining and contracting works, instead of its diffusion and waste through lateral channels and outlets, as the underlying principle of any correct system of improvement of the Mississippi River. In this conclusion it was considered that flood conditions ruled in the determination of the capacity and in the formation of abnormal extremes and inequalities of width and depth, causing obstructions both to flood discharge and low-water navigation. Therefore, the plan of improvement should include the control of floods in order to succeed in such general improvement as is described in the organic act creating the Commission, and in the river and harbor bill of August 2, 1882. This fact, characteristic to an unusual extent of the Mississippi River, is apparent when it is remembered that the mean duration of overflowing floods or those rising above the banks at the different gauge stations is from 50 to 100 days, and in many years, at many stations, from 100 to 160 days and even more. Thus, the flood conditions rule not only by their violence but by their duration.

While it was believed that the studies and experience of engineers on sedimentary streams had collected much evidence in favor of such conclusions, it was still considered necessary by the Commission to undertake a careful and extensive project, first, of surveys (to be extended finally over the entire basin), and second, of instrumental observations upon the size and form of the bed and the changes therein; the velocity and its distribution; the mutual relation of stage, velocity, area, and discharge; the phenomena of floods and low water; the amount and manner of transportation of solid matter, and other kindred problems. These surveys and observations had for their immediate object such accurate knowledge of the river and of its laws as would enable the Commission to devise the most sure and economical methods of applying the adopted principles to its improvement. Though yet incomplete, they have progressed far enough, when supplemented by the work of other observers, to add much testimony to the correctness of the theoretical conclusions of the Commission, to establish important truths upon which any plan of improvement must be founded, and, in general, to enable the Commission more safely to adopt the details and order of execution of improvement works. It is known that the rate of progress of the apex of a flood-wave of sufficient height to allow escape by overflow is much slower than that of a wave contained within the banks. The subsidence of an overflowing flood is also much retarded, as compared with one which has been restrained within either natural or artificial banks. It is also known that a large part of the solid matter moved by the force of the stream from above, to form obstructing bars below, passes on or very near the bottom, and that outlets, therefore, while decreasing the ability of the stream to do its work, or its volume and velocity, do not proportionately diminish the work required to be done or the burden of solid matter to be moved. The Commission is now prepared to recommend, as part of a complete system of channel improvement, levees of the following description:

The standard of elevation for levees should be sufficient to confine floods most frequently recurring with the intention of producing the maximum effect of channel improvement at a minimum of cost. Th, restraint of those great floods, which recur only at long intervals would involve a cost disproportionate to the injury which would be in

flicted upon the maintenance and improvement of the channel by overflows occurring at such intervals. The system should be generally one of restraint in the interest of navigation. The extent to which it should be carried with this object would be determined by considerations of economy. At outlets and depressions of the bank, where the height of levees would make them particularly important as a part of the plan, they are most liable to destruction and costly to rebuild. They have also particular importance at the heads of the great basins, from the pressure upon them and from the destructive character of the floods, to the work below, which their loss would produce. At such localities entire security should be given by greater widths, and grades above any expected flood. The height of no one recorded flood can be adopted throughout the lower river as a standard of elevation, for all floods show local peculiarities of slope resulting from the causes combining to produce them; and also because these recorded relative elevations are liable to be further changed by the continuous erection of levees. Such a standard of elevation can only be judiciously adopted after the reduction and analysis of the surveys and observations of this and previous years. From the same sources will also be obtained reliable information concerning the cost of such levees.

It is proper that this recommendation should be accompanied by the statement that while levees judiciously erected under the system we have indicated would produce the maximum effect in channel improvement at a minimum of cost, they would not be of a sufficient height to protect the adjacent lands from overflow during great floods.

A discussion of the physics of the river with particular reference to the topic of this part of the report has been prepared by Professor Mitchell. It is herewith submitted as Appendix S.

Of the appropriation of $4,123,000, made by the river and harbor bill of August 2, 1882, the Commission considered, at a series of meetings ending August 28, 1882, that the sum of $1,300,000 could be judiciously expended in closing existing breaks in levees as a part of the plan to afford ease and safety to the navigation and commerce of the Mississippi River, and to deepen the channel. While this amount was greater than the estimate for that object accompanying the report of November 25, 1881, it was largely within the recommendation of a supplementary report, dated March 22, 1882, and made necessary by the unprecedented flood of 1882, which greatly increased the gaps to be closed. This supplementary report was transmitted with a special message from the President.

The considerations controlling the use of this allotment of $1,300,000 were as follows: It was deemed expedient to apply it first upon the lowest parts of the river flowing along the fronts of the great basins wherever the State organizations were unable to close the gaps, and thence upward, as far as the allotment would extend, with the intention that such enlargement and improvement of the channel as would result from levees should be secured on the lower part of the river below Cairo, to prepare it for the accumulated waters from above, excluded from the reservoir basins. For it was considered that in the progress of levee building the extension of the work from below upwards would have less tendency to produce a temporary increase of flood height, and of overflow, in the upper parts of the river below Cairo than would the extension of levees from above downwards have upon the lower parts of the same river. The prudence of this method of procedure is clearly indicated in the history of levee building on the river. It was also thought expedient to first close new breaks, which

presumably would inflict new injuries upon navigation if allowed to remain open, rather than old ones, whose effects had been to a certain degree ultimated. These new breaks had principally occurred in the fronts whose restoration is first undertaken.

It was furthermore believed that a greater effect in channel improvement would be accomplished by giving the greatest possible development in length to the levees, even at grades no higher than those previously existing, and proved insufficient for great floods, rather than by giving an entirely secure height to a less length of new work. After mature deliberation the chance of an early repetition of so great a flood as that of 1882 was deemed to involve less prospective risk to channel maintenance and improvement than the incontinuity of the line during an average flood.

Under this project it was anticipated, with such prices as had been ruling for State levee work, that the allotment made would be sufficient, in co-operation with the local and State funds, to entirely confine the river, in any ordinary flood, to its bed along the front of the Atchafalaya, Tensas, and Yazoo basins. It proved, however, in consequence of the very late period when the appropriation became a law, and of the large amount of work to be completed in a limited time, that higher rates were demanded by contractors, thus rendering it necessary that some gaps in the line should remain unclosed under the present allotment. Others were also left open by the failure of some of the local assistance promised.

To put this project into execution the Secretary of War was requested to convene, in a Board, the executive officers of the several engineer districts of the river in which gaps were to be closed. It was the duty of this Board, under the instructions of the Commission, to ascertain the extent of the work and to apply the fund placed at its disposal by the Commission proportionately to the amount of required work in closing the existing gaps in the fronts of the Atchafalaya, the Tensas, and the Yazoo basins; omitting such parts of the work as could be undertaken by the States in which the basins lie; and, as far as found practicable and expedient, after the local information to be acquired, extending the work in each basin from below upwards.

Their investigations led to the final subdivision of the allotment by them as follows: To the Atchafalaya Basin, $110,000; to the Tensas, $750,000, and to the Yazoo, $440,000. The action of this Board in distributing the allotments and in deciding what gaps should remain unclosed in consequence of its insufficiency has been approved by the Commission. The reports of the Board and of the district engineer officers composing it are submitted as Appendices K, L, M, and R.

An effort was made in September of this year by the State of Louisiana, the Mississippi Valley Railroad, and private parties to raise a sufficient fund to close the Bonnet Carré crevasse. They were successful to within $15,000 of the amount required. The Commission was requested to supply the deficiency, and thus by the expenditure of a comparatively small sum, secure the completion of a work costing $80,000 or $90,000, and closing an outlet which had been discharging for eight years at nearly all stages of the river.

Under these circumstances the Commission complied with the request, making a further allotment of $15,000 for closing existing gaps contingent upon the successful completion of the Bonnet Carré levee by the other parties to the work.

In the work of surveys, location, and preparation of notes and maps for the closing of gaps, the services and advice of the engineer bureaus

of the States of Mississippi and Louisiana, in charge of Mr. G. M. Helm and Mr. H. B. Richardson, were freely rendered and proved of very great assistance.

It will be understood from what has been said that the levees for the closure of breaks in which provision was made as stated, were not in all cases such as would be recommended by the Commission as part of a system of channel improvement. But as the breaks in them exposed the river to rapid depletion of its water along a portion of its course where such depletion would be, it was believed, specially injurious to navigation, it was thought to be in the interest of economy to attempt to close them as far as possible at once.

LEGISLATION.

The Commission renews the recommendation heretofore offered, that provision be made by law for the appropriation, by suitable proceedings, of land and material necessary in any work of Mississippi River improvement undertaken by the government. So long as the engineers in charge of the works shall be obliged, as they are at present, to rely upon negotiation with private owners for all material used by them, they will be liable to suffer unreasonable exactions. Some slight embarrassments from this source have been experienced already. The piles, poles, and brush largely used in all works of channel improvement have, practically, no market value at most places where they are found. But at the extravagant prices which owners sometimes put upon them, when wanted by the government, they make a large item in the cost of the work. It is not believed that there would be necessity for frequent resort to proceedings for condemnation of property if it were authorized. The possession of the power would, in most cases, be a sufficient preventive of extortion. But in extreme cases it might save large expenditures for material and larger losses from delay.

It is desirable also that the rights of the government to the free use for purposes of channel improvements of material found on bars and islands within the river banks should be distinctly declared and defined. There is much material in these localities which ought, in justice, to be applicable to the improvement of the river without payment to any one; and the extent to which such use may lawfully be made ought to be clearly stated by law.

It is also important that provision be made for retaining control by the government over areas of land reclaimed and built up from the river bed by works of channel improvement. Whether such tracts of land, comprising in some cases hundreds of acres, made at the expense of the government, are to be regarded as the property of riparian owners or not, it is indispensable that the possession and control of them shall remain in the government as long as may be necessary for the complete execution of its purposes.

It is recommended, also, that provision be made by law for the punishment of persons making or assisting to make any cut-off at any neck or bend in the Mississippi River, or in any manner interfering, without authority of law, with its channel or banks, or any work of improvement projected by the government. The inevitable effect of a cut-off is to produce sudden increase of velocity in its vicinity, which in turn is necessarily followed by violent caving, rapid changes of channel, and a general disturbance of equilibrium which it requires a long time to restore. Such consequences, besides being in themselves disastrous, would render any work of channel improvement in that locality impossible—it

might be for years. It has occurred in the past more than once that a cut-off has been made by the lawless acts of individuals, and in the present situation of the river such an event is not impossible in the absence of suitable legal penalties.

OTHER APPENDICES.

As having a bearing upon the work of improvement in shallower portions of the river, a report has been prepared by a committee relative to the relations of bends to the river depths and widths in the portion of the river now free from all obstruction to navigation. This report appears as Appendix N.

Under the head of outlets and levees reference has been made to a survey ordered in the neighborhood of Cubitt's Gap, with a view to determine whether the shoaling of the main river below is still in progress. Two reports upon this crevasse, by officers of the Coast and Geodetic Survey, not heretofore published, have been kindly furnished at our request by the Superintendent of that service, and appear as Appendices O and O 1. From the same source we have also a report by Prof. George Little, concerning the *blue clay* of the Mississippi River, which appears as Appendix P.

A paper by Dr. Frank L. James, entitled "A memoir to accompany a map of Mississippi County, Arkansas," which furnishes an instructive physical description of the swamp region and its overflow, is offered in Appendix Q.

From much of that part of the preceding report which relates to levees, one member (General Comstock) dissents.

For the following reasons he is of the opinion that levees are of little aid in the improvement of low-water navigation:

Low-water navigation is now bad only where the river has such great widths as to be necessarily shoal. To improve it the great widths must be diminished by works of contraction, and the river must be kept from wandering about, by revetting its caving banks. Both these classes of work are in the river, and levees on top of the bank cannot take the place of either class.

It is true that when levees confine floods between them they increase the depth of 60 feet or more which the river would have without them, by a few feet, and thus should increase somewhat the velocity of the river. Theoretically, this increased velocity should scour the bed, thus sinking it in some degree. In practice no case is known where any considerable sinking of the river bed for long distances has been produced by levees.

But even if the low-water surface and the river bed should sink together in consequence of the levee effect during preceding floods, it is still to be feared that the low-water depths might not be sensibly increased thereby.

In view of the uncertainty whether levees will cause any considerable sinking of the low-water bed, and of the further doubt whether such sinking would sensibly increase the low-water depths, it does not seem to him wise, in the absence of practical experience, to attribute any considerable value to a system of levees as an aid to channel improvement.

The same member doubts at present the advisability of raising levees on the banks of the river, above the present grades. The observations on the great flood of 1882, made by the Commission, although not yet fully reduced, seem to show that if all the water of the river were confined between levees, the discharge would, in many places, be from 60 to 80 per cent. greater than that flowing in the river when its banks are

full. It is a grave question whether, in any sufficient and thorough levee plan, such enormous discharges will not require the main levees to be far apart, in order to give a large cross-section to the flood-flow. Should this prove necessary, the levees close to the banks should not, in his opinion, be raised above the present grades, and any money available after that was accomplished should be applied to the great main levees, which would not follow the windings of the river.

All of which is respectfully submitted.

C. B. COMSTOCK,
Lieutenant-Colonel of Engineers and Brevet Brigadier-General,
President Mississippi River Commission.
CHAS. R. SUTER,
Major of Engineers, U. S. A.
HENRY MITCHELL,
Coast and Geodetic Survey.
B. M. HARROD.
ROBERT S. TAYLOR.

Note.—General Q. A. Gillmore has been prevented by severe illness from participating in the preparation of this report, and is, at the date of signing, unable to hear it read.

S. S. L.

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APPENDICES.

APPENDIX A.

ANNUAL REPORT OF THE SECRETARY OF THE COMMISSION UPON THE FIELD WORK OF SURVEYS AND EXAMINATIONS.

OFFICE OF MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
Saint Louis, August 7, 1882.

GENERAL: I have the honor to submit the following report upon the field work of surveys during the fiscal year ending June 30, 1882:

Outfit.—All floating property has been kept in the best condition possible by current repairs. Survey boats 3 and 4, lying at Mound City, and mentioned in last report as quite unserviceable, have since been sunk in a storm, and were on October 20th, 1881, inspected and condemned by Capt. J. B. Quinn, Corps of Engineers. The boats, Mississippi, Tennessee, Louisiana, Arkansas, and Pioneer, have gradually deteriorated notwithstanding the constant repairs, and should as soon as practicable be overhauled. The roofs, especially, should be entirely renewed.

Several skiffs have been condemned and the completement filled by purchase.

Four iron steam launches were purchased in October, 1881. They have been quite successful in the work for which they were designed, and their defects having been discovered and remedied, they are now better boats than when new.

Instruments.—Most of the topographical instruments are old and much worn. Such are now being generally repaired and some are being fitted for compass work. One current meter has been purchased and one made.

Organization and methods.—In triangulation and precise leveling no changes are to be noted, except the adoption in the former of a target consisting of a frame of telegraph wire on which are tightly stretched strips of black and white signal cloth. This form gives no phase, as the surface pointed at is a plane, and the strips of cloth are about equally illuminated, whether the sun be in front of or behind the target.

The scope of the topographical work was much enlarged; a complete survey, with 5-foot contours, being carried back an average distance of three-quarters of a mile on each side of the river. The organization and methods are fully described in a report by Assistant Ockerson, which has been submitted.

A radical change was made in the organization of the trans-alluvial level party. The party was reduced by dispensing with the topographer and his assistants. To enable the leveler to keep the traverse as well, the telescope of a Stackpole level was, by a very simple contrivance, attached to the limb of a Würdemann transit. This combined instrument worked admirably in both capacities, the discrepancies both in elevation and azimuth being as small as could be expected from separate instruments and observers. The progress of the reduced party is not materially less than before.

Progress and cost.—In all branches of work the rate of progress continues to improve with the added experience of the parties, the grade of work being fully maintained if not increased.

Triangulation was carried from Grafton to Keokuk, a distance by river of about 166 miles. From a base on the west bank of the Des Moines Rapids Canal near the middle lock, the system (not including small triangles in developing from the bases) extends through six triangles and six quadrilaterals to a base on the C. B. & Q. railroad opposite Louisiana, then through eight triangles and six quadrilaterals to the Grafton base. These lines (with the exceptions noted) are from 3 to 18 miles in length. The stations were on the bluffs on each side of the valley, and a system of flag stations was placed on the river bank, at intervals of 3 to 4 miles. These were located by intersections from the triangulation stations.

Near the close of the work Assistant Wisner was sent to Grafton, Louisiana, and Keokuk to measure the bases with the secondary tubes, and to determine the azimuths of the two former, the last having been determined by Assistant Eisenmann.

The following is a summary of this work:

Number of stations occupied	48
Number of flag stations located	60
Number of public buildings located	18
Secondary bases located and measured with steel tape	2
Tertiary bases measured	4
Azimuths determined	1

Secondary angles read	160
Location angles read	200
Number of days in the field	82
Miles of river covered	166
Average per month (miles)	61
Total field cost	$6,816 43
Cost per mile of river	41 00
Cost of measurement of three bases	442 00

Precise levels also were completed from Keokuk to Grafton, with a length of line of 243km (151 miles), including two river crossings, in a field season of 94 days, of which 73 were working days.

Ten miles were re-run, because the discrepancies exceeded the limit, and fourteen miles of triplicate line were run because the discrepancies, though within the limit, were considered too large.

The total field cost of the work was $4,154.59, giving a cost per mile of line of $27.

The work was done with two instruments in the same party.

Trans-alluvial levels were completed on line No. 2 (west from first Chickasaw Bluffs), and No. 4 (east from Helena). Work was begun on October 23, 1881, and discontinued on account of high water on February 1, 1882. During this time 55 miles of line were run at a total cost of $3,101.91, or $56 per mile.

The topographical work may be summarized as follows:

First party, Saint Louis Landing to Arkansas City:

Number of miles of river	110
Number square miles of topography	263
Number square miles of hydrography	70
Total area surveyed, square miles	306
Total field cost	$17,863 77
Cost per mile of river	162 00
Cost per square mile of survey	58 00

Second party, Greenville to Lake Providence:

Number of miles of river	63
Number square miles of topography	120
Number square miles of hydrography	40
Total area surveyed, square miles	160
Total field cost	$19,436 74
Cost per mile of river	309 00
Cost per square mile of survey	121 00

For both parties:

Total area surveyed, square miles	466
Cost per square mile	$90 00

Parties for gauging the river and collecting physical data were maintained on the Upper Mississippi River at Prescott, Winona, Clayton, Hannibal, Grafton, and Saint Louis, until the latter part of October, 1881, when they were transferred to Paducah on the Ohio, and Columbus, Helena, Hays' Landing, and Red River Landing on the Mississippi, at which points they are still at work. The sixth party was disbanded.

For the successful prosecution of this work, the committee is principally indebted to the zeal and efficiency of the assistant engineers and other employés with whom it has been my good fortune to be associated. The chiefs of party deserve the heartiest commendation, and they unite in testifying to the industry and ability of their subordinates.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers,
Secretary Mississippi River Commission.

Gen. C. B. COMSTOCK,
Chairman of Committee on Surveys and Examinations.

APPENDIX B.

FINAL REPORT UPON A SECONDARY TRIANGULATION OF THE MISSISSIPPI RIVER BETWEEN HELENA ISLAND AND GREENVILLE, MISS., EXECUTED UNDER THE ORDERS OF THE MISSISSIPPI RIVER COMMISSION, 1880–'81.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., December 1, 1882.

GENERAL: I have the honor to submit herewith a memorandum compiled from the records of this office, relative to the secondary triangulation from Helena Island

to Greenville, accompanied by the results in tabular form, a sketch of the system, and a report of Assistant G. Y. Wisner upon the final adjustment, the whole intended to form a final report upon this portion of the work.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary.

General C. B. COMSTOCK,
Chairman of Committee on Surveys and Examinations.

I. The system is composed of 225 stations, situated on or near the banks of the river. They are connected by 44 quadrilaterals and 134 single triangles.

II. The work depends on the following known lines:

1. The side Buckshot–Helena Island No. 2 (stations 224 and 225).

This line was furnished from the office of the Lake Survey. It depends for length and azimuth upon a secondary base at Harbert's Point, and for the co-ordinates of its extremities upon the Memphis astronomical post. It is in the eleventh triangle from the base, its length 1,648.9 meters. (For description of base and triangulation, see Report of Chief of Engineers, 1879, Part III, p. 1929.)

2. The line Ude–Glendale (Stations 220, 221), furnished from the office of the Coast and Geodetic Survey. This line depends for length and azimuth upon a secondary base at Helena, and for the co-ordinates of its extremities upon an astronomical station at the same place. Its length, as furnished by the Superintendent of the Coast and Geodetic Survey, is 3,898.1 meters. It is in the second triangle from the base.

3. A secondary base at Greenville, measured by a party of the Coast and Geodetic Survey. The length and azimuth of this base, with the co-ordinates of one of its extremities, were furnished from the office of that survey. The length of the base is 2,071.97 meters.

III. The following instruments were used:

Repsold universal instrument, No. 1. Diameter of horizontal limb, twelve inches. Limb graduated to four minutes, reading by two microscopes to two seconds. Angles measured in order around the station, positive and negative, direct and reversed. Eight sets were taken uniformly distributed over the limb, giving sixteen pointings at each station.

Gambey-Würdemann No. 1. Diameter of horizontal limb, ten inches. Limb graduated to five minutes, reading by verniers to five seconds. Programme same as for the Repsold, except that twelve sets, giving twenty-four pointings, were taken.

Gambey No. 2. Diameter of horizontal limb, six inches. Limb graduated to ten minutes, reading by verniers to ten seconds. Single angles read in repetitions of threes. Readings positive and negative, direct and reversed. Six sets, uniformly distributed over the limb, and giving thirty-six pointings at each station, were taken.

Pistor and Martin universal instrument. Diameter of horizontal limb, five inches. Limb graduated to ten minutes, reading by two microscopes to ten seconds. (Single seconds estimated.) Programme same as for the Repsold, except that six double sets, at intervals of 30°, giving thirty-six pointings at each station, were taken.

Troughten & Simms, No. 1 (10-inch). Diameter of horizontal limb, ten inches. Limb graduated to five minutes, reading by two microscopes to one second. Programme same as for the Repsold.

None of the instruments closed the horizon. The limit of closure of triangles was six seconds. The instruments were mounted on portable tripods made of scantling, framed and bolted together. They were 6, 8, and 12 feet in height, the former being seldom used. When timber was convenient, stations were in some cases built and left standing. The observer stood on a platform disconnected from the instrument support.

The stations were marked by stones 3 feet in length, dressed to 6 by 6 inches at one end, the balance rough. A small hole was drilled in the top. They were planted vertically, the top projecting but a few inches above ground.

The targets were octagonal poles, of 3 inches diameter for the upper and 1 inch for the lower part of the work. They were covered with zones of black and white cloth. A nail in the bottom was set into the hole in the top of the stone, and the target was then plumbed. When the station was occupied, the target was removed and reset before leaving. The verticality of the target was tested when the station was visited for the purpose of removing the tripod.

IV. For the preliminary reduction, single triangles were adjusted to closure, side equations being neglected.

The lengths and azimuths of sides were then computed from the upper to the lower end of the work, showing discrepancies in 219 triangles of 1 in 1,000 in length and 26.6 seconds in azimuth.

The final adjustment was then made as described in the accompanying report of Mr. Wisner, and the geodetic co-ordinates of the points computed.

The following tables give the results of the work.

Tabulated results of secondary triangulation from Greenville to Helena.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
1	South Base	51 54 39.76	39.79	*2,071.97	*204 49 50.35	*33 23 18.19	*91 04 32.44
2	North Base	84 12 30.01	29.94	2,352.64	109 02 38.84	*33 24 19.23	*91 03 58.77
3	Point Chicot	43 52 50.04	50.27	2,973.92	332 54 41.71	33 24 44.14	91 05 24.84
		59.81	00.00				
2	North Base	42 20 53.67	53.21	2,352.64	109 02 38.84	.....	.....
3	Point Chicot	98 25 10.40	10.25	2,505.78	190 36 41.22	.....	.....
4	Point Chicot Tow Head	39 13 56.73	56.54	3,679.70	331 22 54.50	33 26 04.08	91 05 06.98
		00.80	00.00				
3	Point Chicot	52 47 29.82	29.29	2,505.78	190 36 41.22	.....	.....
4	Point Chicot Tow Head	63 21 59.19	58.93	2,223.42	307 14 52.13	.....	.....
5	Island 83	63 50 32.16	31.78	2,495.47	63 24 58.09	33 25 20.40	91 03 58.47
		01.17	00.00				
4	Point Chicot Tow Head	109 29 37.13	36.96	2,223.42	307 14 52.13	.....	.....
5	Island 83	29 37 32.05	30.10	3,202.41	156 52 59.97	.....	.....
6	Argyle	40 52 53.82	52.94	1,679.28	17 45 26.09	33 26 55.99	91 04 47.15
		03.00	00.00				
4	Point Chicot Tow Head	52 10 41.89	41.45	1,679.28	197 45 15.16	.....	.....
6	Argyle	69 53 31.34	30.32	1,565.37	87 38 56.41	.....	.....
7	Campbell	57 55 48.85	48.23	1,860.89	325 34 11.28	33 26 53.91	91 05 47.71
		02.08	00.00				
4	Point Chicot Tow Head	75 18 45.35	45.83	1,860.89	145 34 33.73	.....	.....
7	Campbell	61 55 52.61	53.60	2,651.57	27 30 04.88	.....	.....
8	Wallwood	42 45 21.68	20.57	2,418.75	250 14 59.33	33 25 37.56	91 06 35.10
		59.64	00.00				
7	Campbell	31 30 54.05	53.09	2,651.57	27 30 04.88	.....	.....
8	Wallwood	62 37 18.81	17.55	1,389.64	144 52 21.21	.....	.....
9	Carter	85 51 51.03	49.36	2,360.71	239 00 14.81	33 26 14.45	91 07 06.06
		03.89	00.00				
8	Wallwood	42 39 08.90	08.21	1,389.64	144 52 21.21	.....	.....
9	Carter	77 46 20.44	19.68	1,091.91	42 38 23.85	.....	.....
10	Solona	59 34 32 62	32.11	1,575.00	282 12 40.18	33 25 48.37	91 07 34.70
		01.96	00.00				
9	Carter	58 15 21.46	21.37	1,091.91	42 38 23.85	.....	.....
10	Solona	74 31 08.10	08.16	1,265.03	148 06 59.91	.....	.....
11	Randolph	47 13 30.28	30.47	1,433.59	280 53 15.19	33 26 23.23	91 08 00.57
		59.84	00.00				
9	Carter	45 32 46.95	46.24	1,433.59	100 53 45.22	.....	.....
11	Randolph	69 45 08.54	07.83	1,131.87	211 08 07.36	.....	.....
12	Torpley	64 42 05.92	05.93	1,487.67	326 26 13.94	33 26 54.68	91 07 37.91
		01.41	00.00				
11	Randolph	40 18 48.93	48.73	1,131.87	211 08 07.36	.....	.....
12	Torpley	101 16 08.46	09.15	1,178.47	132 24 29.02	.....	.....
13	South Island 82	38 25 01.38	02.12	1,786.41	350 49 12.57	33 27 20.47	91 08 11.60
		58.77	00.00				
12	Torpley	66 56 17.78	18.47	1,178.47	132 24 29.02	.....	.....
13	South Island 82	76 45 54.96	56.14	1,831.72	235 38 14.31	.....	.....
14	Ashland	36 17 46.64	45.39	1,937.94	19 21 01.20	33 27 54.03	91 07 13.05
		59.38	00.00				
13	South Island 82	51 05 40.13	39.31	1,831.72	235 38 14.31	.....	.....
14	Ashland	79 43 49.69	48.32	1,883.67	135 22 34.91	.....	.....
15	Warner	49 10 32.42	32.37	2,381.83	4 32 39.02	33 28 37.54	91 08 04.30
		02.24	00.00				
14	Ashland	33 17 03.74	03.68	1,883.67	135 22 34.91	.....	.....
15	Warner	73 38 50.47	49.95	1,080.59	241 43 16.70	.....	.....
16	Miller's Bend	73 04 05.67	06.37	1,889.37	348 39 30.68	33 28 54.16	91 07 27.44
		59.88	00.00				
15	Warner	74 25 28.34	28.86	1,080.59	241 43 16.70	.....	.....
16	Miller's Bend	72 42 21.01	22.08	1,917.94	134 25 59.14	.....	.....
17	Morris	32 52 07.43	09.06	1,901.04	347 17 38.93	33 29 37.74	91 08 20.50
		56.78	00.00				

* The length and azimuth of the line South Base, North Base, and the co-ordinates of its extremities were furnished by the United States Coast and Geodetic Survey, and are assumed as correct.

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
15	Warner	55 07 21.02	21.81	1,901.04	167 17 47.86		
17	Morris	79 11 59.18	58.75	2,179.94	66 29 37.68		
18	North Island 82	45 40 38.60	39.44	2,610.17	292 09 34.39	33 29 09.51	91 09 37.92
		58.80	00.00				
17	Morris	59 00 24.70	25.41	2,179.94	66 29 37.68		
18	North Island 82	44 19 48.24	48.65	1,920.51	202 09 06.30		
19	Shady Side	76 39 45.51	45.94	1,565.55	305 29 35.86	33 30 07.24	91 09 09.88
		58.45	00.00				
18	North Island 82	70 20 58.10	57.12	1,920.51	202 09 06.30		
19	Shady Side	51 42 03.24	01.77	2,133.89	73 51 23.58		
20	Moss Lake	57 57 01.52	01.11	1,778.20	311 47 40.86	33 29 47.97	91 10 29.28
		02.86	00.00				
18	North Island 82	55 15 26.36	25.10	1,778.20	131 48 09.20		
20	Moss Lake	86 42 39.93	39.46	2,371.65	38 30 20.34		
21	Phillips	38 01 56.83	55.44	2,881.46	256 31 44.22	33 28 47.73	91 11 26.47
		03.12	00.00				
20	Moss Lake	30 36 14.39	14.77	2,371.65	38 30 20.34		
21	Phillips	62 09 42.37	42.75	1,208.82	280 39 31.53		
22	Point Comfort	87 14 01.92	02.48	2,099.62	187 53 59.39	33 28 40.47	91 10 40.46
		58.68	00.00				
21	Phillips	77 16 44.23	45.06	1,208.82	280 39 31.53		
22	Point Comfort	74 04 13.34	13.87	2,459.32	26 35 43.04		
23	Scott	28 39 00.48	01.07	2,424.39	177 56 18.46	33 27 29.08	91 11 23.08
		58.05	00.00				
21	Phillips	26 58 06.97	08.14	2,424.39	357 56 16.60		
23	Scott	95 05 43.80	43.86	1,297.39	82 50 34.60		
24	Barnes	57 56 07.35	08.00	2,849.49	204 53 59.13	33 27 23.83	91 12 12.93
		58.12	00.00				
23	Scott	29 54 59.10	58.55	1,297.39	82 50 34.60		
24	Barnes	117 08 50.13	49.60	1,190.07	19 58 56.73		
25	Panther Forest	32 56 12.03	11.85	2,123.31	232 54 59.90	33 26 47.53	91 12 28.68
		01.26	00.00				
24	Barnes	93 02 20.18	20.99	1,190.07	19 58 56.73		
25	Panther Forest	53 25 44.65	45.63	2,151.35	146 33 02.42		
26	Sand Point	33 31 52.41	53.38	1,730.23	293 00 43.73	33 27 45.79	91 13 14.60
		57.24	00.00				
25	Panther Forest	53 19 51.31	52.32	2,151.35	146 33 02.42		
26	Sand Point	55 43 03.98	04.92	1,825.57	22 15 42.03		
27	Rowdy Bend	70 57 01.60	02.76	1,880.59	273 12 30.03	33 26 50.95	91 13 41.37
		56.89	00.00				
26	Sand Point	73 21 58.73	59.22	1,825.57	22 15 42.03		
27	Rowdy Bend	55 17 56.62	56.24	2,240.22	146 57 31.03		
28	Gaines' Landing	51 20 04.24	04.54	1,922.19	275 37 00.41	33 27 51.90	91 14 28.68
		59.59	00.00				
26	Sand Point	38 58 41.84	41.60	1,922.19	95 37 41.26		
28	Gaines' Landing	84 35 06.18	04.69	1,451.02	191 01 55.74		
29	Mud Creek	56 26 15.80	13.71	2,296.48	314 35 47.98	33 28 38.13	91 14 17.93
		03.82	00.00				
28	Gaines' Landing	41 58 38.57	38.14	1,451.02	191 01 55.74		
29	Mud Creek	108 02 10.09	09.96	1,941.77	262 59 51.73		
30	Ashbrook	29 59 12.01	11.90	2,760.55	53 01 21.03	33 28 45.81	91 13 03.28
		00.67	00.00				
29	Mud Creek	33 44 07.12	08.36	1,941.77	262 59 51.73		
30	Ashbrook	115 24 15.97	15.91	2,102.36	198 24 48.84		
31	Island 81	30 51 35.03	35.73	3,419.52	49 16 38.76	33 29 50.55	91 12 37.55
		58.12	00.00				
30	Ashbrook	29 27 09.25	08.71	2,102.36	198 24 48.84		
31	Island 81	112 03 55.51	56.21	1,661.24	266 21 06.84		
32	Eutopia	38 28 53.91	55.08	3,131.08	47 52 47.23	33 29 53.98	91 11 33.33
		58.67	00.00				
31	Island 81	69 50 59.85	02.09	1,661.24	266 21 06.84		
32	Eutopia	58 28 02.27	03.31	1,987.77	144 49 45.63		
33	Island 80	51 40 53.07	54.60	1,804.72	16 30 15.74	33 30 46.72	91 12 17 70
		55.19	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
32	Eutopia	43 53 50.44	50.47	1,987.77	144 49 45.63		
33	Island 80	75 26 39.95	39.85	1,581.09	249 22 41.29		
34	Offutt	60 39 29.83	29.68	2,207.11	8 43 43.29	33 31 04.79	91 11 20.36
		00.22	00.00				
33	Island 80	59 29 34.40	33.78	1,581.09	249 22 41.29		
34	Offutt	85 35 34.24	33.41	2,380.01	154 58 46.40		
35	Port Anderson	34 54 52.93	52.81	2,754.26	9 53 17.66	33 32 14.79	91 11 59.37
		01.57	00.00				
33	Island 80	23 27 49.41	48.68	2,754.26	189 53 07.54		
35	Port Anderson	92 38 03.94	03.97	1,221.15	102 31 21.63		
36	Eunice	63 54 07.59	07.35	3,063.71	346 25 03.45	33 32 23.38	91 12 45.58
		00.94	00.00				
35	Port Anderson	39 45 25.61	27.28	1,221.15	102 31 21.63		
36	Eunice	103 31 41.30	41.57	1,306.37	178 59 14.53		
37	Duncan	36 42 50.07	51.15	1.985.99	322 16 22.91	33 33 05.78	91 12 46.47
		56.98	00.00				
36	Eunice	30 12 54.68	53.73	1,306.37	178 59 14.53		
37	Duncan	109 59 54.06	54.33	1,027.33	108 59 08.39		
38	Palmetto	39 47 11.78	11.94	1,918.33	328 45 59.52	33 33 16.62	91 13 24.13
		00.52	00.00				
37	Duncan	60 57 47.56	47.81	1,027.33	108 59 08.39		
38	Palmetto	91 16 36.19	36.79	1,928.45	197 42 10.79		
39	Ivy Point	27 45 35.27	35.40	2,205 14	349 56 47.96	33 34 16.25	91 13 01.40
		59.02	00.00				
38	Palmetto	34 54 08.45	09.71	1,928.45	197 42 10.79		
39	Ivy Point	72 32 31.11	31.69	1,156.63	90 14 55.05		
40	Yellow Bend	72 33 16.62	18.60	1,928.31	342 47 48.85	33 34 16.41	91 13 46.24
		56.18	00.00				
39	Ivy Point	106 48 15.01	16.09	1,156.63	90 14 55.05		
40	Yellow Bend	43 10 50.28	51.24	2,213.49	227 03 39.01		
41	Bar Point	30 00 53.38	52.67	1,582.27	17 03 21.12	33 35 05.36	91 12 43.41
		58.67	00.00				
40	Yellow Bend	29 35 06.71	06.88	2,213.49	227 03 39.01		
41	Bar Point	75 12 06.01	06.85	1,130.27	122 16 20.64		
42	Duffin	75 12 43.93	46.27	2,213.38	17 28 46.41	33 35 24,94	91 13 20.47
		56.65	00.00				
41	Bar Point	67 06 03.07	01.44	1,130.27	122 16 20.64		
42	Duffin	77 34 34.61	33.70	1,800.77	224 41 26.44		
43	Arkansas City	35 19 26.92	24.86	1,909.06	9 22 28.78	33 36 06.49	91 12 31.35
		04.60	00.00				
42	Duffin	31 20 19.10	19.04	1,800.77	224 41 26.44		
43	Arkansas City	113 43 36.20	36.52	1,635.53	290 58 17.12		
44	Shelby	34 56 04.14	04.44	2,878.87	76 02 45.48	33 35 47.49	91 11 32.11
		59.44	00.00				
43	Arkansas City	37 27 51.18	51.56	1,635.53	290 58 17.12		
44	Shelby	84 50 29.32	29.29	1,177.04	195 49 19.19		
45	White Hill	57 41 38.65	39.15	1,927.23	73 31 05.23	33 36 24.25	91 11 19.67
		59.15	00.00				
44	Shelby	67 29 56.36	56.36	1,177.04	195 49 19.19		
45	White Hill	75 27 17.74	18.18	1,805.00	300 22 07.90		
46	Delolme	37 02 45.03	45.46	1,891.11	83 19 55.89	33 35 54.63	91 10 19.27
		59.13	00.00				
45	White Hill	45 48 59.30	58.80	1,805.00	300 22 07.90		
46	Delolme	89 05 24.88	24.55	1,827.55	209 28 05.90		
47	Island 78	45 05 36.41	36.65	2,548.18	74 34 01.85	33 36 46.27	91 09 44.39
		00.59	00.00				
46	Delolme	63 50 25.38	25.31	1,827.55	209 28 05.90		
47	Island 78	63 20 52.01	52.99	2,059.06	326 07 32.20		
48	Mound Place	52 48 39.91	41.70	2,050.29	93 19 15.13	33 35 50.78	91 08 59.88
		57.30	00.00				
47	Island 78	51 15 18.19	18.62	2,059.06	326 07 32.20		
48	Mound Place	81 10 53.11	53.64	2,176.01	227 18 50.51		
49	Easton	47 33 47.38	47.74	2,756.99	94 53 12.59	33 36 38.67	91 07 57.83
		58.68	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
47	Island 78	63 57 01.04	01.27	2,756.99	274 52 13.60		
49	Easton	26 54 26.99	27.20	2,477.19	121 47 39.79		
50	South Choctaw	89 08 30.97	31.53	1,247.82	30 55 26.10	33 37 21.02	91 09 19.52
		59.00	00.00				
49	Easton	40 17 29.71	28.90	2,477.19	121 47 39.79		
50	South Choctaw	83 23 33.04	32.55	1,925.15	218 23 22.02		
51	Childers	56 18 59.14	58.55	2,957.22	342 04 49.18	33 38 09.99	91 08 33.13
		01.89	00.00				
50	South Choctaw	65 37 19.52	18.18	1,925.15	218 23 22.02		
51	Childers	60 13 16.62	14.93	2,163.14	98 37 02.66		
52	North Choctaw	54 09 26.58	26.89	2,061.27	332 45 43.58	33 38 20.50	91 09 56.12
		02.72	00.00				
51	Childers	31 39 28.25	26.66	2,163.14	98 37 02.66		
52	North Choctaw	72 30 52.38	52.94	1,170.94	206 05 23.75		
53	Eutaw	75 49 41.37	40.40	2,127.95	310 15 54.44	33 38 54.64	91 09 36.14
		02.00	00.00				
52	North Choctaw	82 24 03.65	04.34	1,170.94	206 05 23.75		
53	Eutaw	64 36 13.83	14.04	2,131.24	90 41 48.88		
54	Chicot	32 59 41.47	41.62	1,942.44	303 40 44.67	33 38 55.47	91 10 58.84
		58.95	00.00				
53	Eutaw	30 37 32.67	33.40	2,131.24	90 41 48.88		
54	Chicot	93 32 54.60	55.71	1,31239	17 7 08 07.34		
55	Rock Head	55 49 28.66	30.89	2,571.24	301 18 35.06	33 39 38.01	91 11 01.39
		55.93	00.00				
54	Chicot	38 04 08.02	08.63	1,312.39	177 08 07.34		
55	Rock Head	97 29 32.43	33.00	1,155.81	94 37 38.95		
56	Mitchell	44 26 17.53	18.37	1,858.45	319 03 32.54	33 39 41.03	91 11 46.10
		57.98	00.00				
55	Rock Head	53 24 26.96	25.66	1,155.81	94 37 38.95		
56	Mitchell	91 20 57.21	56.43	1,608.14	183 16 17.74		
57	Pigeon Point	35 14 38.64	37.91	2,002.38	328 01 41.83	33 40 33.15	91 11 42.54
		02.81	00.00				
56	Mitchell	37 43 40.60	38.75	1,608.14	183 16 17.74		
57	Pigeon Point	78 25 17.68	16.58	1,096.23	81 41 36.32		
58	Chicora	63 51 06.62	04.67	1,755.04	325 32 17.64	33 40 28.00	91 12 24.65
		04.90	00.00				
57	Pigeon Point	54 09 03.97	04.75	1,096.23	81 41 36.32		
58	Chicora	93 39 04.24	05.76	1,667.62	168 02 07.23		
59	Sabenden	32 11 49.14	49.49	2,053.18	315 50 10.30	33 41 20.95	91 12 38.08
		57.35	00.00				
58	Chicora	28 49 53.00	52.71	1,667.62	168 02 07.23		
59	Sabenden	111 07 38.10	38.08	1,250.00	236 54 21.71		
60	Island 77	40 02 29.00	29.21	2,417.89	16 52 15.08	33 41 43.10	91 11 57.41
		00.10	00.00				
59	Sabenden	48 49 14.05	14.55	1,250.00	236 54 21.71		
60	Island 77	81 26 30.63	31.28	1,232.91	138 21 15.57		
61	Lucca	49 44 12.77	14.17	1,619.85	8 05 12.09	33 42 13.00	91 12 29.23
		57.45	00.00				
60	Island 77	65 32 15.57	17.23	1,232.91	138 21 15.57		
61	Lucca	68 06 90.53	02.10	1,550.69	250 14 55.82		
62	Cypress Tow Head	46 21 40.69	40.67	1,580.68	23 53 46.62	33 42 30.01	91 11 32.55
		56.79	00.00				
61	Lucca	40 57 33.08	32.80	1,550.69	250 14 55.82		
62	Cypress Tow Head	92 13 35.82	34.36	1,394.11	162 29 01.65		
63	Cypress Creek	46 48 54.10	52.84	2,125.12	29 17 45.45	33 43 13.16	91 11 48.85
		03.00	00.00				
62	Cypress Tow Head	99 42 47.63	47.70	1,394.11	162 29 01.65		
63	Cypress Creek	44 49 06.97	06.70	2,368.15	297 39 45.91		
64	Singer	35 28 05.08	05.60	1,693.50	82 12 25.52	33 42 37.47	91 10 27.39
		59.68	00.00				
63	Cypress Creek	54 36 54.13	54.19	2,368.15	297 39 45.91		
64	Singer	39 17 36.24	35.45	1,935.21	156 58 06.57		
65	Cane	86 05 30.84	30.36	1,503.22	63 03 20.61	33 43 35.28	91 10 56.80
		01.21	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
64	Singer	77 24 04.66	04.22	1,935.21	156 58 06.57		
65	Cane	47 54 39.35	39.72	2,314.43	289 03 10.53		
66	Good Luck	54 41 16.80	16.06	1,759.93	54 22 41.64	33 43 10.75	91 09 31.84
		00.81	00.00				
64	Singer	66 01 34.21	33.82	1,759.93	234 22 10.80		
66	Good Luck	67 35 40.07	39.92	2,221.36	346 47 01.72		
67	Catfish Point	46 22 46.48	46.26	2,247.56	120 24 26.42	33 42 00.56	91 09 12.12
		00.76	00.00				
66	Good Luck	34 39 44.87	44.51	2,221.36	346 47 01.72		
67	Catfish Point	93 45 43.66	43.27	1,612.62	260 32 55.93		
68	Wilkinson	51 34 32.33	32.22	2,829.32	132 08 02.42	33 42 09.15	91 08 10.34
		00.86	00.00				
67	Catfish Point	75 30 44.36	45.60	1,612.62	260 32 55.93		
68	Wilkinson	69 55 21.45	22.61	2,752.08	10 38 07.59		
69	Catfish Tow Head	34 33 51.65	51.79	2,669.73	156 04 04.88	33 40 41.36	91 08 30.06
		57.46	00.00				
68	Wilkinson	43 16 37.60	37.86	2,752.08	10 38 07.59		
69	Catfish Tow Head	64 57 59.15	58.73	1,986.48	255 35 55.40		
70	Jersey Point	71 45 23.12	23.41	2,625.53	147 22 00.23	33 40 57.39	91 07 15.36
		59.87	00.00				
69	Catfish Tow Head	47 28 34.14	34.20	1,986.48	255 35 55.40		
70	Jersey Point	83 28 16.59	17.04	1,938.32	352 08 19.78		
71	Content	49 03 09.16	08.76	2,612.97	123 05 16.74	33 39 55.07	91 07 05.07
		59.89	00.00				
70	Jersey Point	42 22 51.18	51.48	1,938.32	352 08 19.78		
71	Content	69 01 34.11	34.16	1,403.35	241 09 59.66		
72	Turner	68 35 33.39	34.36	1,944.01	129 46 00.48	33 40 17.03	91 06 17.35
		58.68	00.00				
71	Content	35 37 00.25	00.54	1,403.35	241 09 59.66		
72	Turner	104 48 57.79	58.43	1,283.02	316 21 27.69		
73	Kentucky Landing	39 34 00.45	01.03	2,129.88	96 47 45.73	33 39 46.90	91 05 42.98
		58.49	00.00				
72	Turner	54 29 27.00	26.92	1,283.02	316 21 27.69		
73	Kentucky Landing	83 04 25.24	25.23	1,547.82	219 26 11.99		
74	Cook	42 26 07.56	07.85	1,887.57	81 52 41.00	33 40 25.69	91 05 04.81
		59.80	00 00				
73	Kentucky Landing	40 35 55.12	55.80	1,547.82	219 26 11.99		
74	Cook	84 37 09.01	09.68	1,232.94	314 49 23.47		
75	Buck Ridge	54 46 53.35	54.52	1,886.26	80 02 47.79	33 39 57.49	91 04 30.87
		57.48	00.00				
74	Cook	42 32 31.52	31.41	1,232.94	314 49 23.47		
75	Buck Ridge	110 53 46.12	45.49	1,864.24	245 43 27.80		
76	Island 76	26 33 43.90	43.10	2,575.88	92 17 47.47	33 40 22.36	91 03 24.90
		01.54	00.00				
74	Cook	49 07 16.66	16.68	2,575.88	272 16 52.09		
76	Island 76	67 46 41.46	42.32	2,183.91	160 04 29.79		
77	Cork's Point	63 05 59.30	06.00	2,673.87	43 10 14.77	33 41 29.00	91 03 53.80
		57.42	00.00				
76	Island 76	35 02 54.64	54.30	2,183.91	160 04 29.79		
77	Cork Point	101 36 14.12	14.12	1,827.08	238 27 59.65		
78	Russett	43 20 51.63	51.58	3,116.55	15 07 41.64	33 42 00.01	91 02 53.33
		00.39	00.00				
77	Cork Point	48 50 31.99	32.51	1,827.08	238 27 59 65		
78	Russett	86 18 39.92	40.34	1,950.64	144 47 13.56		
79	Mohawk Landing	44 50 46.42	47.15	2,585.47	9 37 36.47	33 42 51.73	91 03 37.01
		58.33	00.00				
78	Russett	38 31 51.88	52.90	1,950 64	144 47 13.56		
79	Mohawk Landing	102 01 55.30	56.27	1,912.94	66 48 45.61		
80	Coryes	39 26 11.36	10.83	3,003.35	286 14 18.54	33 42 27.28	91 04 45.30
		58.54	00.00				
79	Mohawk Landing	30 26 42.13	42.24	1,912.94	66 48 45.61		
80	Coryes	82 05 39 87	39.18	1,049.47	164 42 28.53		
81	Deer Point	67 27 38.49	38.58	2,051.46	277 14 44.00	33 43 00 14	91 04 56.05
		00.49	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
80	Coryes	59 53 12.56	13.09	1,049.47	164 42 28.53		
81	Deer Point	85 12 49.80	49.96	1,586.75	69 55 12.54		
82	Hayden	34 53 56.93	56.95	1,827.92	284 48 37.36	33 42 42.45	91 05 53.93
		59.29	00.00				
81	Deer Point	40 44 59.86	00.42	1,586.75	69 55 12.54		
82	Hayden	74 23 40.66	41.73	1,144.20	175 30 58.68		
83	Willow Point	64 51 15.60	17.85	1,688.25	290 39 38.94	33 43 19.48	91 05 57.40
		56.12	00.00				
82	Hayden	55 46 41.16	42.10	1,144.20	175 30 58.68		
83	Willow Point	85 51 24.03	24.37	1,524.33	81 22 21.14		
84	Deadwood	38 21 53.56	53.53	1,838.68	299 43 42.17	33 43 12.05	91 06 55.94
		58.75	00.00				
83	Willow Point	43 35 59.00	58.65	1,524.33	81 22 21.14		
84	Deadwood	96 54 13.01	12.96	1,652.74	164 27 35.68		
85	Dry Chute	39 29 47.89	48.39	2,379.24	304 57 37.76	33 44 03.73	91 07 13.14
		59.90	00.00				
84	Deadwood	38 51 54.29	54.94	1,652.74	164 27 35.68		
85	Dry Chute	109 23 19.11	19.73	1,971.06	93 50 45.86		
86	Oak Landing	31 44 44.35	45.33	2,963.04	305 34 48.76	33 44 08.01	91 08 29.53
		57.75	00.00				
85	Dry Chute	45 20 10.73	10.34	1,971.06	93 50 45.86		
86	Oak Landing	69 36 44.72	44.62	1,546.19	204 13 18.81		
87	Meadow Point	65 03 05.28	05.04	2,037.74	319 10 27.48	33 44 53.78	91 08 04.88
		00.73	00.00				
86	Oak Landing	29 55 57.50	58.13	1,546.19	204.13 18.81		
87	Meadow Point	104 15 16.03	16.69	1,075.95	128 28 49.21		
88	Williams	45 48 44.24	45.18	2,089.89	354 17 16.21	33 45 15.51	91 08 37.61
		57.77	00.00				
87	Meadow Point	93 58 16.48	15.70	1,075.95	128 28 49.21		
88	Williams	53 29 43.01	42.56	1,995.85	254 58 48.47		
89	Wildwood	32 32 01.89	01.74	1,608.14	42 27 28.37	33 45 32.29	91 07 22.71
		01.38	00.00				
88	Williams	43 00 33.94	33.90	1,995.85	254 58 48.47		
89	Wildwood	67 21 40.28	40.66	1,452.23	142 21 10.77		
90	Crow Point	69 37 44.77	45.44	1,964.92	31 58 37.05	33 46 09.61	91 07 57.18
		58.99	00.00				
89	Wildwood	97 18 22.57	20.83	1,452.23	142 21 10.77		
90	Crow Point	41 52 15.55	15.70	2,203.43	280 28 35.91		
91	Ozark	40 49 25.27	23.47	1,482.73	59 39 59.24	33 45 56.60	91 06 32.98
		03.39	00.00				
89	Wildwood	31 30 21.66	21.62	1,482.73	239 39 31.60		
91	Ozark	109 37 30.80	31.12	1,234.76	310 02 28.12		
92	Fisher	38 52 06.97	07.26	2,225.52	91 10 41.29	33 45 30.82	91 05 56.25
		59.43	00.00				
91	Ozark	74 41 31.15	32.09	1,234.76	310 02 28.12		
92	Fisher	73 47 25.30	24.82	2,278.20	203 50 13.37		
93	Thorn Point	31 31 05.44	03.09	2,268.10	55 21 36.35	33 46 38.45	91 05 20.47
		01.89	00.00				
92	Fisher	27 47 11.02	10.00	2,278.20	203 50 13.37		
93	Thorn Point	112 55 30.02	30.04	1,677.16	270 55 03.22		
94	Prentiss	39 17 18.57	19.96	3,313.58	51 38 19.52	33 46 37.58	91 04 15.29
		59.61	00.00				
93	Thorn Point	60 31 02.17	01.83	1,677.16	270 55 03.22		
94	Prentiss	76 27 41.92	41.46	2,139.89	167 23 20.94		
95	Napoleon	43 01 16.88	16.71	2,389.91	30 24 27.55	33 47 45.35	91 04 33.45
		00.97	00.00				
94	Prentiss	31 14 38.19	36.73	2,139.93	167 23 20.94		
95	Napoleon	99 26 31.67	31.40	1,463.72	247 56 39.44		
96	Beulah Lake	49 18 51.79	51.87	2,783.79	18 38 16.93	33 48 03.19	91 03 40.71
		01.65	00.00				
95	Napoleon	30 41 05.94	04.71	1,463.72	247 56 39.44		
96	Beulah Lake	122 38 33.81	33.43	1,663.98	190 35 42.25		
97	Wright's Point No. 2	26 40 20.83	21.86	2,745.69	37 16 10.73	33 48 56.28	91 03 28.82
		00.58	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
96	Beulah Lake	52 48 13.02	13.20	1,663.98	190 35 42.25		
97	Wright's Point No. 2	60 40 02.18	02.65	1,445.04	71 15 51.52		
98	Arkansas River	66 31 43.23	44.15	1,581.50	317 47 06.06	33 48 41.21	91 04 22.02
		58.43	00.00				
97	Wright's Point No. 2	109 04 38.02	38.12	1,445.04	71 15 51.52		
98	Arkansas River	43 22 57.08	57.15	2,953.63	207 52 24.76		
99	Middle Ground	27 32 23.65	24.73	2,146.65	00 20 29.95	33 50 05.95	91 03 28.32
		58.75	00.00				
98	Arkansas River	29 42 08.02	08.02	2,953.63	207 52 24.76		
99	Middle Ground	75 07 12.92	14.18	1,513.89	312 45 40.50		
100	Pride's Point	75 10 36.56	37.80	2,952.86	57 35 26.78	33 49 32.59	91 02 45.10
		57.50	00.00				
99	Middle Ground	82 35 41.67	39.70	1,513.89	312 45 40.50		
100	Pride's Point	69 01 34.79	32.72	3,158.44	201 47 37.32		
101	Floryville	28 22 48.33	47.58	2,973.98	50 10 50.30	33 51 07.77	91 01 59.48
		04.79	00.00				
100	Pride's Point	31 03 12.19	11.24	3,158.44	201 47 37.32		
101	Floryville	88 48 17.60	17.50	1,878.57	110 36 20.24		
102	Melona	60 08 30.83	31.26	3,641.07	350 44 13.39	33 51 29.22	91 03 07.89
		00.62	00.00				
101	Floryville	41 29 51.88	51.90	1,878.57	110 36 20.24		
102	Melona	99 47 52.08	52.97	1,990.62	190 47 49.18		
103	Ezell	38 42 13.65	15.13	2,960.48	332 05 42.14	33 52 32.69	91 02 53.38
		57.61	00.00				
102	Melona	30 14 05.62	05.81	1,990.62	190 47 49.18		
103	Ezell	119 20 44.58	45.64	1,979.72	130 08 42.93		
104	Frank J	30 25 06.25	08.55	3,427.04	340 33 18.65	33 53 14.11	91 03 52.27
		56.45	00.00				
103	Ezell	35 12 12.81	32.47	1,979.72	130 08 42.93		
104	Frank J	101 38 42.92	43.63	1,669.11	208 29 26.47		
105	Terrene	43 08 42.71	43.90	2,835.35	345 20 59.85	33 54 01.73	91 03 21.28
		58.44	00.00				
104	Frank J	33 18 28.33	26.81	1,669.11	208 29 26.47		
105	Terrene	71 32 51.67	50.90	948.25	100 02 34.65		
106	Cumbyville	75 08 42.71	42.29	1,638.04	355 10 56.69	33 54 07.09	91 03 57.62
		02.71	00.00				
105	Terrene	104 29 20.83	20.92	948.25	100 02 34.65		
106	Cumbyville	50 27 44.69	44.53	2,168.46	229 34 29.87		
108	Waxhaw	25 02 53.73	54.55	1,727.27	24 32 11.17	33 54 52.72	91 02 53.36
		59.25	00.00				
106	Cumbeyville	28 43 30.21	29.38	2,778.22	200 51 00.51		
107	White River	49 55 51.95	53.12	1,361.83	330 55 28.87	33 55 31.36	91 03 19.12
108	Waxhaw	101 20 37.25	37.50	2,168.46	49 35 05.72		
		59.41	00.00				
107	White River	87 06 02.29	01.94	1,361.83	330 55 28.87		
108	Waxhaw	58 59 21.67	21.16	2,437.89	209 55 04.40		
109	Stokes	33 54 36.31	36.90	2,092.12	63 50 07.75	33 56 01.30	91 02 06.02
		00.27	00.00				
108	Waxhaw	33 41 19.54	18.70	2,437.89	209 55 04.40		
109	Stokes	87 53 59.69	59.59	1,587.45	117 49 30.46		
110	Sibley	58 24 41.25	41.71	2,860.01	356 13 41.65	33 56 25.35	91 03 00.68
		00.48	00.00				
109	Stokes	52 54 04.40	03.61	1,587.45	117 49 30.46		
110	Sibley	98 36 31.56	31.81	2,654.34	199 12 28.15		
112	Victoria	28 29 23.65	24.58	3,290.44	350 43 22.57	33 57 46.70	91 02 26.67
		59.61	00.00				
110	Sibley	26 30 35.94	36.72	1,780.13	172 41 51.43		
111	Bradley	116 40 12.29	13.71	1,325.85	236 01 32.80	33 57 22.66	91 03 09.49
112	Victoria	36 49 08.96	09.57	2,654.34	19 12 47.15		
		57.19	00.00				
111	Bradley	39 43 35.10	33.69	1,325.85	236 01 32.80		
112	Victoria	95 51 40.63	39.79	1,210.84	151 53 36.53		
113	Concordia Bayou	44 24 46.56	46.52	1,884.64	16 18 10.64	33 58 21.37	91 02 48.89
		02.29	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
112	Victoria	42 32 02 19	02.06	1,210.84	151 53 36.53		
113	Concordia Bayou	95 17 27.39	27.75	1,219.18	67 10 51.89		
114	Montgomery	42 10 28.96	30.19	1,795.77	289 20 57.62	33 58 06.02	91 03 32.66
		58.54	00.00				
113	Concordia Bayou	71 40 10.52	08.25	1,219.18	67 10 51.89		
114	Montgomery	71 03 13.85	12.76	1,910.79	176 07 14.67		
115	Gill	37 16 40.62	38.99	1,903.88	318 50 32.87	33 59 07.89	91 03 37.70
		04.99	00.00				
114	Montgomery	24 42 21.25	20.63	1,910.79	176 07 14.67		
115	Gill	80 59 35.73	36.74	829.57	77 06 48.60		
116	Betsley	74 18 59.90	02.63	1,960.36	331 24 33.64	33 59 01.89	91 04 09.20
		56.88	00.00				
115	Gill	88 03 14.90	15.25	829.57	77 06 48.60		
116	Betsley	49 35 43.85	44.36	1,230 74	207 30 46.65		
117	Widow	42 20 59.38	21 00.39	937.73	345 09 58.64	33 59 37.32	91 03 47.05
		58.13	00.00				
116	Betsley	64 11 29.27	29.49	1,230.74	207 30 46.65		
117	Widow	75 33 52.79	53.12	1,715.03	103 04 52.15		
118	Cassell	40 14 36.15	37.39	1,844.90	323 18 53.19	33 59 49.91	91 04 52.14
		58.21	00.00				
117	Widow	42 43 21.52	19.70	1,715.03	103 04 52.15		
118	Cassell	94 09 30.10	29.13	1,702.27	188 54 46.69		
119	Henley	43 07 11.67	11.17	2,502.48	325 47 41.27	34 00 44.49	91 04 41 86
		03.29	00.00				
118	Cassell	54 03 42.29	42.21	1,702.27	188 54 46.69		
119	Henley	69 03 16.46	17.01	1,645.51	299 51 35.45		
120	Scrub Grass	56 53 00.00	00.78	1,898.12	62 59 05.77	34 00 17.90	91 03 46.25
		58.75	00.00				
119	Henley	67 14 15.83	14.70	1,645.51	299 51 35.45		
120	Scrub Grass	73 53 54.06	53.01	2,418.21	193 45 59.56		
121	Black Oak	38 51 52.40	52.29	2,519.58	52 38 04.40	34 01 34.13	91 03 23.82
		02.29	00.00				
120	Scrub Grass	45 31 36.88	37.35	2,418.21	193 45 59.56		
121	Black Oak	79 07 55.41	56.67	2,097.87	294 38 15.44		
122	Graddys	55 20 24.48	25.98	2,887.19	59 18 31.06	34 01 05.73	91 02 09.50
		56.77	00.00				
121	Black Oak	31 01 00.62	00.19	2,097.87	294 38 15.44		
122	Graddys	104 05 40.00	40.78	1,531.75	10 33 16.26		
123	Smith's Point	44 53 17.81	19.03	2,883.12	145 39 51.11	34 00 16.86	91 02 20.43
		58.43	00.00				
122	Graddys	60 36 20.99	21.82	1,531.75	10 33 16.26		
123	Smith's Point	84 34 39.90	40.90	2,337.48	275 07 51.04		
124	Foot of 70	34 48 55.21	57.28	2,670.85	129 57 39.08	34 00 10.06	91 00 49.71
		56.10	00.00				
123	Smith's Point	44 36 53:33	52.74	2,337.48	275 07 51.04		
124	Foot of 70	65 17 16.25	16.47	1,745.98	29 51 25.33		
125	Antlers	70 05 50.52.	50.79	2,258.30	139 45 15.60	33 59 20.92	91 01 23.58
		00.10	00.00				
124	Foot of 70	42 08 35.42	35.21	1,745.98	29 51 25.33		
125	Antlers	96 00 13.34	13.63	1,755.82	305 51 20.02		
127	Peak	41 51 10.00	11.16	2,602.43	167 43 02.19	33 58 47.54	91 00 28.14
		58.76	00.00				
125	Antlers	30 41 46.88	47.80	1,713.92	275 09 32.24		
126	Land's End	77 10 14.27	16.36	919.28	17 59 53.05	33 59 15.90	91 00 17.07
127	Peak	72 07 54.06	55.84	1,755.82	125 51 51.01		
		55.21	00.00				
126	Land's End	71 40 33.96	33.32	919.28	17 59 53.05		
127	Peak	49 59 35.42	34.54	1,025.34	247 59 21.40		
128	Bee Hive	58 19 51.56	52.14	827.32	126 19 34.24	33 59 00.01	90 59 51.11
		00.94	00.00				
127	Peak	58 50 01.35	01.95	1,025.34	247 59 21.40		
128	Bee Hive	59 53 50.63	49.35	1,000.53	8 05 52.75		
129	R. Jones	61 16 08.33	08.70	1,011.59	126 49 41.02	33 58 27.85	90 59 56.60
		00.31	00.00				

Tabulated results of secondary triangulations from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
128	Bee Hive	72 00 58.52	57.80	1,000.53	8 05 52.75		
129	R. Jones	56 51 55.42	54.72	1,222.50	244 57 44.48		
130	Hill	51 07 07.50	07.48	1,076.29	116 05 16.08	33 58 44.65	90 59 13.45
		01.44	00.00				
129	R. Jones	48 07 30.04	30.23	1,222.50	244 57 44.48		
130	Hill	103 51 46.15	47.08	1,938.18	321 06 21.52		
131	Judge E	28 00 40.79	42.69	2,527.15	113 06 05.32	33 57 55.68	90 58 26.05
		56.98	00.00				
130	Hill	73 24 35.62	35.41	1,938.18	321 06 21.52		
131	Judge E	46 10 50.08	49.88	2,136.09	187 17 37.89		
132	Brandenburg	60 24 34.38	34.71	1,608.19	67 42 18.53	33 59 04.45	90 58 15.48
		00.08	00.00				
131	Judge E	35 31 19.56	18.32	2,136.09	187 17 37.89		
132	Brandenburg	103 43 56.46	56.27	1,901.46	263 33 47.57		
133	South Base	40 44 45.06	45.41	3,179.13	42 49 43.31	33 59 11.37	90 57 01.86
		01.08	00.00				
132	Brandenburg	55 35 21.88	20.93	1,901.46	263 33 47.57		
133	South Base	35 46 28.00	27.29	1,569.16	119 20 56.03		
135	Island 71	88 38 12.29	11.78	1,111.90	27 58 38.02	33 59 36.32	90 57 55.16
		02.17	00.00				
333	South Base	79 36 17.09	15.14	1,339.33	198 57 11.17		
134	North Base	55 36 56.77	55.66	1,870.19	74 34 16.31	33 59 52.48	90 56 44.91
135	Island 71	44 46 49.17	49.20	1,569.16	299 20 26.24		
		03.03	00.00				
134	North Base	58 07 35.62	35.88	1,870.19	74 34 16.31		
135	Island 71	72 24 47.40	48.24	2,089.86	182 08 48.81		
137	Chute of 70	49 27 34.27	35.88	2,345.91	312 41 14.64	34 00 44.10	90 57 52.10
		57.29	00.00				
135	Island 71	30 51 32.50	32.82	1,862.65	213 00 21.63		
136	Oasis	86 20 08.31	09.70	1,074.15	119 20 53.45	34 00 27.02	90 57 15.61
137	Chute of 70	62 48 15.94	17.48	2,089.86	2 08 50.52		
		56.75	00.00				
136	Oasis	83 58 20.02	20.77	1,074.15	119 20 53.45		
137	Chute of 70	52 57 19.17	20.16	1,564.19	246 23 12.88		
138	Sandford	43 04 17.60	19.07	1,255.43	23 19 25.06	34 01 04.44	90 56 56.25
		56.79	00.00				
137	Chute of 70	38 56 27.81	27.06	1,564.19	246 23 12.88		
138	Sanford	100 25 49.27	49.10	1,509.81	166 49 33.23		
139	Warfield	40 37 43.12	43.84	2,362.48	27 27 09.59	34 01 52.15	90 57 09.66
		00.20	00.00				
138	Sanford	51 31 22.19	23.52	1,509.81	166 49 33.23		
139	Warfield	79 14 44.06	46.06	1,560.67	267 34 39.71		
140	Magenta	49 13 48.06	50.42	1,958.54	38 21 23.31	34 01 54.29	90 56 08.87
		54.31	00.00				
139	Warfield	35 43 21.77	21.43	1,560.67	267 34 39.71		
140	Magenta	64 32 52.60	52.94	926.05	152 08 06.67		
141	Laconia	79 43 45.00	45.63	1,432.15	51 51 42.86	34 02 20.86	90 56 25.74
		59.37	00.00				
140	Magenta	54 01 41.10	39.91	926.05	152 08 06.67		
141	Laconia	93 48 43.96	43.39	1,407.99	238 19 13.84		
142	Hard Luck	32 09 36.46	36.70	1,735.91	26 10 03.31	34 02 44.85	90 55 39.03
		01.52	00.00				
141	Laconia	45 52 23.96	22.39	1,407.99	238 19 13.84		
142	Hard Luck	91 29 38.44	37.65	1,492.17	326 50 02.36		
143	Hurricane Point	42 38 00.25	37 59.96	2,078.11	104 12 20.21	34 02 04.31	90 55 07.21
		02.65	00.00				
142	Hard Luck	33 22 46.15	46.16	1,492.17	326 50 02.36		
143	Hurricane Point	108 15 01.88	02.64	1,322.57	255 05 22.81		
144	Dennis	38 22 09.48	11.20	2,282.95	113 28 01.92	34 02 15.36	90 54 17.38
		57.51	00.00				
143	Hurricane Point	46 21 16.85	15.99	1,322.57	255 05 22.81		
144	Dennis	100 51 52.81	52.37	1,767.62	175 57 43.09		
146	Burtnett	32 46 50.94	51.64	2,398.95	28 44 32.02	34 03 12.58	90 54 22.23
		00.60	00.00				

Tabulated results of secondary triangulations from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
144	Dennis	42 51 13.33	13.32	1,569.80	218 48 56.43		
145	Dyers	77 09 42.42	43.23	1,233.03	115 59 01.14	34 02 55.05	90 53 39.02
146	Burtnett	59 59 02.60	03.45	1,767.62	355 57 40.38		
		58.35	00.00				
145	Dyers	79 00 36.79	36.48	1,233.03	115 59 01.14		
146	Burtnett	68 16 50.83	50.81	2,239.97	227 41 46.13		
147	Australia	32 42 31.94	32.71	2,119.82	14 59 49.62	34 04 01.51	90 53 17.63
		59.56	00.00				
146	Burtnett	43 04 15.52	16.29	2,239.97	227 41 46.13		
147	Australia	79 08 57.73	58.98	1,808.14	126 51 21.33		
148	Island 69	57 46 42.92	44.73	2,600.38	4 37 34.45	34 04 36.71	90 54 14.06
		56.17	00.00				
147	Australia	30 12 43.94	42.82	1,808.14	126 51 21.33		
148	Island 69	116 20 52.81	52.93	1,651.09	190 29 56.79		
149	Saint John's	33 26 23.38	24.25	2,940.32	337 03 39.12	34 05 29.39	90 54 02.32
		00.13	00.00				
148	Island 69	49 53 25.62	26.33	1,651.09	190 29 56.79		
149	Saint John's	80 54 58.96	55 00.02	1,668.33	91 25 03.39		
150	Beith's Point	49 11 31.88	33.65	2,154.00	320 36 00.59	34 05 30.72	90 55 07.37
		56.46	00.00				
149	Saint John's	42 27 10.13	10.15	1,668.33	91 25 03.39		
150	Beith's Point	104 11 36.77	37.64	2,048.19	167 12 49.30		
151	Parker	33 21 10.58	12.21	2,941.79	313 51 27.18	34 06 35.55	90 55 25.05
		57.48	00.00				
150	Beith's Point	30 13 52.50	50.04	2,048.19	167 12 49.30		
151	Parker	94 12 29.99	28.40	1,250.37	81 25 07.79		
152	Minork	55 33 42.55	41.56	2,476.76	316 58 22.32	34 06 29.50	90 56 13.29
		05.04	00.00				
151	Parker	53 20 20.35	19.78	1,250.37	81 25 07.79		
152	Minork	71 48 31.77	31.85	1,226.68	189 36 08.91		
153	Crews	54 51 08.04	08.37	1,452.76	314 45 05.02	34 07 08.75	90 56 05.31
		00.16	00.00				
152	Minork	38 29 28.96	29.34	1,226.68	189 36 08.91		
153	Crews	108 03 05.46	06.43	1,384.86	117 39 19.82		
154	Fowler	33 27 22.14	24.23	2,115.52	331 06 17.22	34 07 29.61	90 56 53.18
		56.56	00.00				
153	Crews	48 13 01.52	12 59.61	1,384.86	117 39 19.82		
154	Fowler	100 06 29.48	28.30	1,966.54	197 32 24.71		
155	Island 68	31 40 32.46	32.09	2,596.35	345 52 05.61	34 08 30.47	90 56 30.04
		03.46	00.00				
154	Fowler	27 34 26.51	26.56	1,966.54	197 32 24.71		
155	Island 68	109 26 30.48	31.53	1,335.16	126 59 09.23		
156	Island 67	42 59 00.10	01.91	2,719.90	349 57 47.79	34 08 56.54	90 57 11.68
		57.09	00.00				
155	Island 68	58 59 09.29	08.87	1,335.16	126 59 09.23		
156	Island 67	90 20 20.73	20.86	2,242.95	216 38 25.04		
157	Zenor	30 40 29.27	30.27	2,617.05	5 58 24.12	34 09 54.94	90 56 19.41
		59.29	00.00				
156	Island 67	39 03 21.35	20.14	2,242.95	216 38 25.04		
157	Zenor	90 31 19.06	18.80	1,833.54	306 07 35.61		
158	Pushmataha	50 25 21.00	21.06	2,909.92	75 42 47.01	34 09 19.85	90 55 21.60
		01.41	00.00				
157	Zenor	33 47 13.75	13.03	1,833.54	306 07 35.61		
158	Pushmataha	116 48 37.42	37.44	2,076.91	242 56 45.51		
159	Knowlton	29 24 08.23	09.53	3,333.26	92 21 35.59	34 09 50.51	90 54 09.39
		59.40	00.00				
158	Pushmataha	38 57 46.96	46.13	2,076.91	242 56 45.51		
159	Knowlton	103 44 09.27	09.38	2,155.08	319 13 16.68		
160	Anderson	37 18 03.75	04.49	3,329.19	101 55 43.06	34 08 57.54	90 53 14.45
		59.98	00.00				
159	Knowlton	30 00 03.85	03.18	2,155.08	319 13 16.68		
160	Anderson	110 38 07.40	07.63	1,698.99	249 51 55.18		
161	Mohawk	39 21 48.02	49.19	3,179.89	109 14 19.33	34 09 16.51	90 52 12.17
		59.27	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
160	Anderson	31 52 28.54	26.32	1,698.99	249 51 55.18		
161	Mohawk	92 51 49.38	48.33	1,091.73	337 00 41.81		
162	Malone	55 15 46.15	45.35	2,064.89	101 45 05.80	34 08 43.89	90 51 55.52
		04.07	00.00				
161	Mohawk	77 38 18.12	17.98	1,091.73	337 00 41.81		
162	Malone	70 09 31.33	31.15	2,001.09	227 10 22.32		
164	Oliver	32 12 09.90	10.87	1,926.98	79 23 05.36	34 09 28.04	90 50 58.24
		59.35	00.00				
162	Malone	47 00 30.92	30.37	1,503.11	274 10 52.69		
163	New Hope	84 35 28.52	28.60	1,470.25	178 46 54.13	34 08 40.33	90 50 57.01
164	Oliver	48 24 00.83	01.03	2,001.09	47 10 54.49		
		00.27	00.00				
163	New Hope	72 19 41.10	40.03	1,470.25	178 46 54.13		
164	Oliver	77 57 10.00	09.31	2,825.72	280 49 44.16		
165	Robinsonville	29 43 10.44	10.66	2,900.36	71 07 34.33	34 09 10.79	90 49 09.90
		01.54	00.00				
164	Oliver	35 57 39.69	40.37	2,825.72	280 49 44.16		
165	Robinsonville	69 03 20.75	22.10	1,718.05	169 54 07.11		
166	Jones	74 58 55.83	57.53	2,732.35	64 52 58.04	34 10 05.69	90 49 21.65
		56.27	00.00				
165	Robinsonville	30 12 57.73	56.80	1,718.05	169 54 07.11		
166	Jones	106 18 18.23	18.54	1,256.55	243 35 41.97		
167	Sunflower Landing	43 28 43.88	44.66	2,396.41	20 07 21.99	34 10 23.83	90 48 37.70
		59.84	00.00				
166	Jones	76 40 28.12	27.59	1,256.55	243 35 41.97		
167	Sunflower Landing	61 40 56.42	55.85	1,840.08	125 17 02.50		
169	Island 66	41 38 36.25	36.56	1,664.70	346 55 06.13	34 10 58.31	90 49 36.36
		00.79	00.00				
167	Sunflower Landing	35 31 46.07	44.83	2,723.27	160 48 47.35		
168	Richardson	41 05 58.68	59.01	1,626.63	21 54 26.73	34 11 47.29	90 49 12.65
169	Island 66	103 22 16.35	16.16	1,840.08	305 16 29.55		
		01.10	00.00				
168	Richardson	72 08 22.95	22.53	1,626 63	21 54 26.73		
169	Island 66	71 30 20.21	20.17	2,611 81	130 23 53.26		
170	Gratlin	36 21 16.67	17.30	2,602 33	274 01 52.31	34 11 53.25	90 50 54.04
		59.83	00.00				
169	Island 66	30 09 28.23	27.46	2,611 81	130 23 53.26		
170	Gratlin	102 39 16.70	16.81	1,788.55	53 02 26.44		
172	Saint Louis Landing	47 11 14.86	15.73	3,473.85	280 13 10.80	34 11 18.35	90 51 49.86
		59.79	00.00				
170	Gratlin	34 13 41.64	41.37	1,780.27	87 16 07.81		
171	Quitman	73 19 21.15	21.97	1,050.27	340 34 50.74	34 11 50.49	90 52 03.50
172	Saint Louis Landing	72 26 55.84	56.66	1,788.65	233 01 55.07		
		58.63	00.00				
171	Quitman	65 04 27.55	26.70	1,050.27	340 34 50.74		
172	Saint Louis Landing	79 10 14.41	14.04	1,629.99	81 24 44.40		
174	Jack's	35 45 18.96	19.26	1,765.40	225 38 49.77	34 11 10.44	90 52 52.80
		00.92	00.00				
172	Saint Louis Landing	31 27 02.22	02.65	2,544.74	112 51 47.05		
173	Batture	36 23 01.04	03.32	1,433.71	329 13 58.91	34 11 50.42	90 53 21.44
174	Jack's	112 09 52.40	54.03	1,629.99	261 24 09.03		
		55.66	00.00				
173	Batture	102 56 04.37	04.44	1,433.71	329 13 58.91		
174	Jack's	43 34 39.17	39.28	2,532.59	105 39 35.74		
175	Ludlow	33 29 15.42	16.28	1,791.18	252 09 25.95	34 11 32.62	90 54 28.03
		58.96	00.00				
174	Jack's	42 37 24.69	22.95	2,532.49	105 39 35.74		
175	Ludlow	93 50 04.38	03.50	2,489.40	191 48 38.75		
176	Allen	43 32 33.96	33.55	3,667.94	328 16 16.39	34 12 51.70	90 54 08.13
		03.03	00.00				
175	Ludlow	33 16 23.96	23.42	2,489.40	191 48 38.75		
176	Allen	113 53 13.13	13.35	2,518.50	125 42 03.29		
177	Gillem	32 50 21.88	23.23	4,197.32	338 31 41.58	34 13 39.39	90 55 28.03
		58.97	00.00				

Tabulated results of secondary triangulation fnom Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ° ″	° ′ ″	° ′ ″
176	Allen	62 24 37.08	36.77	2,518.50	125 42 03.29		
177	Gillem	80 56 43.44	43.64	3,739.84	224 44 34.71		
178	Dixie's Landing	36 38 38.75	39.59	4,167.10	8 06 53.03	34 15 05.59	90 53 45.14
		59.27	00.00				
177	Gillem	31 56 01.04	00.53	3,739.84	224 44 34.71		
178	Dixie's Landing	84 42 10.62	11.28	2,213.00	320 03 21.34		
179	Jackson's Point	63 21 47.40	48.19	4,166.02	76 42 04.39	34 14 10.52	90 52 49.62
		59.06	00.00				
178	Dixie's Landing	33 06 46.46	44.70	2,213.00	320 03 21.34		
179	Jackson's Point	118 55 17.50	16.51	2,577.93	258 59 09.09		
181	Island 64	27 57 58.44	58.79	4,130.50	106 58 03.54	34 14 26.49	90 51 10.74
		02.40	00.00				
179	Jackson's Point	29 27 00.63	00.00	2,094.71	288 26 09.09		
180	Donaldson	96 45 14.90	15.29	1,276.33	205 12 08.06	34 13 49.01	90 51 31.98
181	Island 64	53 47 44.86	44.71	2,577.93	79 00 04.73		
		59 59	00.00				
180	Donaldson	56 54 35.10	35.03	1,276.33	205 12 08.06		
181	Island 64	68 04 56.77	57.29	1,305.28	317 07 22.74		
182	State Levee	55 00 26.92	27.68	1,445.36	82 07 14.58	34 13 55.44	90 50 36.04
		58.79	00.00				
181	Island 64	71 09 16.56	13.33	1,305.28	317 07 22.74		
182	State Levee	64 56 49.17	45.97	1,781.51	202 04 28.23		
183	Malloy	43 54 03.08	00.70	1,705.31	65 58 43.65	34 14 49.02	90 50 09.87
		08.81	00.00				
182	State Levee	29 40 31.72	31.19	1,781.51	202 04 28.23		
183	Malloy	122 47 34.48	35.21	1,908.11	259 17 07.74		
184	Robson	27 31 51.87	53.60	3,239.88	51 45 55.40	34 15 00.53	90 48 56.60
		58.07	00.00				
183	Malloy	42 28 38.85	39.55	1,908.11	259 17 07.74		
184	Robson	100 02 46.05	47.24	2,117.84	179 20 36.26		
185	Hughey	37 28 31.04	33.21	3,088.04	36 49 08.94	34 16 09.25	90 48 57.54
		55.94	00.00				
184	Robson	40 19 36.81	37.87	2,117.84	179 20 36.26		
185	Hughey	86 12 53.85	55.82	1,705.92	273 07 39.91		
186	Buzzard	53 27 24.06	26.31	2,630.30	39 40 51.11	34 16 06.23	90 47 50.96
		54.72	00.00				
185	Hughey	58 53 26.98	26.92	1,705.92	273 07 39.91		
186	Buzzard	85 44 58.02	58.15	2,523.88	178 53 15.57		
187	Modoc	35 21 33.75	34.93	2,939.71	34 14 49.43	34 17 28.13	90 47 52.86
		58.75	00.00				
186	Buzzard	34 11 07.71	06.96	2,523.88	178 53 15.57		
187	Modoc	62 45 10.92	11.25	1,428.55	296 08 03.25		
188	Hulberton	83 03 41.56	41.79	2,260.38	33 04 49.71	34 17 07.70	90.47 02.72
		00.19	00.00				
187	Modoc	44 08 24.60	25.61	1,428.55	296 08 03.25		
188	Hulberton	92 26 25.73	27.20	1,447.46	208 34 58.70		
189	Paroquet	43 25 04.90	07.19	2,076.54	72 00 21.15	34 17 48.95	90 46 35.64
		55.23	00.00				
188	Hulberton	43 14 08.44	09.12	1,447.46	208 34 58.70		
189	Paroquet	97 07 00.21	01.72	1,553.96	291 28 12.24		
190	Island 63	39 38 47.08	49.16	2,251.07	71 49 54.96	34 17 30.48	90 45 39.10
		55.73	00.00				
189	Paroquet	40 13 45.94	45.62	1,553.96	291 28 12.24		
190	Island 63	88 03 15.42	15.66	1,278.58	199 31 59.78		
191	Island 62	51 42 57.81	58.72	1,978.55	71 15 07.92	34 18 09.59	90 45 22.38
		59.17	00.00				
190	Island 63	46 31 22.81	22.27	1,278.58	199 31 59.78		
191	Island 62	98 52 24.90	25.12	1,633.75	280 39 44.08		
192	Tow Head	34 36 11.67	12,61	2,224.49	66 04 06.87	34 17 59.77	90 44 19.60
		59.38	00.00				
191	Island 62	29 38 03.75	03.28	1,633.75	280 39 44.08		
192	Tow Head	121 00 41.35	41.78	1,647.93	221 41 01.28		
193	Russell	29 21 13.23	14.94	2,856.41	71 02 40.38	34 18 39.71	90 43 36.73
		58.33	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
192	Tow Head	48 47 32.50	32.47	1,647.93	221 41 01.28		
193	Russell	91 23 33.02	33.35	1,936.22	133 04 58.81		
195	Alderson	39 48 52.92	54.18	2,572.89	352 53 21.81	34 19 22.63	90 44 32.04
		58.44	00.00				
193	Russell	29 55 01.88	00.51	2,511.91	162 59 59.32		
194	Overflow	49 11 42.71	42.94	1,275.76	32 11 26.07	34 19 57.67	90 44 05.46
195	Alderson	100 53 16.67	16.55	1,936.22	313 04 27.63		
		01.26	00.00				
194	Overflow	76 40 05.31	04.42	1,275.76	32 11 26.07		
195	Alderson	54 49 19.06	18.50	1,657.22	157 21 52.58		
196	Arbuckle	48 30 37.27	37.08	1,392.06	288 51 01.43	34 20 12.28	90 44 57.00
		01.64	00.00				
195	Alderson	24 41 11.25	10.54	1,657.22	157 21 52.58		
196	Arbuckle	124 21 38.76	39.57	1,345.70	212 59 58.94		
197	State Land	30 57 08.23	09.89	2,659.82	2 03 05.23	34 20 48.90	90 44 28.32
		58.24	00.00				
196	Arbuckle	57 58 49.77	47.95	1,345.70	212 59 58.94		
197	State Land	62 47 49.58	48.19	1,327.99	95 48 03.31		
198	McCullom	59 13 23.27	23 86	1,393.04	335 00 58.02	34 20 53.26	90 45 20.01
		02.62	00.00				
197	State Land	50 09 29.06	27.73	1,327.99	95 48 03.31		
198	McCullom	94 50 23.54	24.12	1,777.60	180 57 10.06		
199	Prewitt	35 00 07.27	08.15	2,306.90	325 57 02.57	34 21 50.94	90 45 18.85
		59.87	00.00				
198	McCullom	27 35 40.31	40.27	1,777.60	180 57 10.06		
199	Prewitt	103 50 09.28	10.86	1,098.23	257 06 59.88		
200	Wilkinson	48 34 08.71	08.87	2,302.11	28 33 14.66	34 21 58.88	90 44 36.95
		58.30	00.00				
199	Prewitt	43 04 49.48	49.44	1,098.23	257 06 59.88		
200	Wilkinson	111 59 22.96	21.69	1,779.58	189 06 45.22		
201	Old Town	24 55 47.87	48.87	2,415.91	34 02 40.32	34 22 55.91	90 44 25.92
		00.31	00 00				
200	Wilkinson	31 39 24.55	24.69	1,779.58	189 06 45.22		
201	Old Town	119 24 03.73	05.04	1,930.03	249 42 46.41		
202	Castile	28 56 28.02	30.27	3,203.78	40 46 56.18	34 23 17.62	90 43 15.05
		56.30	00.00				
201	Old Town	37 10 59.00	58.87	1,930.03	249 42 46.41		
202	Castile	100 11 44.22	45.08	1,722.57	329 31 41.37		
203	Miller's Point	42 37 14.69	16.05	2,805.22	106 54 44.62	34 22 29.43	90 42 40.86
		57.91	00.00				
202	Castile	33 35 08.54	05.93	1,722.57	329 31 41.37		
203	Miller's Point	105 17 39.61	37.75	1,448.91	254 49 38.42		
204	Abbison	41 07 17.29	16.32	2,526.51	115 57 25.67	34 22 41.73	90 41 46.12
		05.44	00.00				
203	Miller's Point	55 26 14.42	15.85	1,448.91	254 49 38.42		
204	Abbison	94 07 02.33	04.37	2,354.82	340 43 04.98		
205	Lucker	30 26 36.87	39.78	2,852.11	130 16 42.37	34 21 29.59	90 41 15.70
		53.62	00.00				
204	Abbison	51 29 54.10	54.41	2,354.82	340 43 04.98		
205	Lucker	65 11 00.52	01.14	2,062.49	225 54 23.29		
206	Kangaroo Point	63 19 08.33	04.45	2,392.10	109 14 00.49	34 22 16.17	90 40 17.72
		57.95	00.00				
205	Lucker	37 21 20.73	19.71	2,062.49	225 54 23.29		
206	Kangaroo Point	109 37 56.25	56.22	2,296.98	296 16 59.85		
207	Ship	33 00 43.33	44.07	3,565.59	83 17 01.27	34 21 43.15	90 38 57.13
		00.31	00.00				
206	Kangaroo Point	63 13 18.75	18.78	2,296.98	296 16 59.85		
207	Ship	51 55 22 71	22.87	2,265.21	168 13 08.21		
208	Westover	64 51 17.71	18.35	1,997.43	53 04 16.37	34 22 55.12	90 39 15.24
		59.17	00.00				
207	Ship	48 25 37.50	37.86	2,265.21	168 13 08.21		
208	Westover	77 31 34.90	35.99	2,093.55	270 41 22.03		
209	Friar's Point	54 02 44.79	46.15	2,732.39	36 39 22.15	34 22 54.28	90 37 53.29
		57.19	00.00				
208	Westover	31 48 05.42	04.37	2,093.55	270 41 22.03		
209	Friar's Point	47 58 08.73	08.50	1,121.07	138 40 16.80		
210	Fort Penny	100 13 47.29	47.13	1,580.18	58 53 47.59	34 23 21.61	90 38 22.27
		01.44	00.00				

Tabulated results of secondary triangulation from Greenville to Helena—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
209	Friar's Point	100 13 38.56	36.72	1,121.07	138 40 16.80		
210	Fort Penny	49 47 57.19	55.42	2,208.22	268 52 05.04		
211	Rozzell	29 58 28.74	27.86	1,713.83	58 54 26.00	34 23 23.01	90 36 55.84
		04.49	00.00				
210	Fort Penny	52 15 39.90	39.75	2,208.22	268 52 05.04		
211	Rozzell	63 55 34.57	34.72	1,946.03	152 48 28.58		
212	Craig	62 48 44.90	45.53	2,210.37	36 36 54.47	34 24 19.19	90 37 30 66
		59.37	00.00				
211	Rozzell	73 45 35.66	34.60	1,946.03	152 48 28.58		
212	Craig	75 15 06.56	05.86	3,628.83	257 33 03.08		
213	Delta	30 59 19.39	19.54	3,655.12	46 35 01.95	34 24 44.55	90 35 11.90
		01.61	00.00				
212	Craig	33 49 01.04	48 59.87	3,628.83	257 33 03.08		
213	Delta	105 50 52.27	51.84	3,120.18	183 25 13.33		
214	Montezuma	40 20 07.81	08.29	5,393.32	43 45 25.77	34 26 25.63	90 35 04.60
		01.12	00.00				
213	Delta	42 10 15.08	15.33	3,120.18	183 25 13.33		
214	Montezuma	87 27 16.46	17.58	2,719.61	275 57 59.93		
215	Yazoo Pass	50 22 25.64	27.09	4,046.99	45 36 32.76	34 26 16.44	90 33 18.66
		57.18	00.00				
214	Montezuma	87 07 14.48	14.65	2,719.61	275 57 59.93		
215	Yazoo Pass	37 16 42.32	42.33	3,291.85	133 15 42.18		
216	Quaw	55 36 02.40	03.02	1,996.36	8 50 52.10	34 27 29.65	90 34 52.57
		59.20	00.00				
215	Yazoo Pass	30 41 32.59	31.16	3,291.85	133 15 42.18		
216	Quaw	101 22 08.44	08.23	2,263.15	211 52 40.85		
217	Belfor	47 56 20.44	20.61	4,346.87	343 56 46.75	34 28 32.01	90 34 05.72
		01.47	00.00				
216	Quaw	45 08 13.44	11.90	2,263.15	211 52 40.85		
217	Belfor	99 50 18.22	17.11	2,794.90	131 43 24.47		
218	Williamson	35 01 31.04	30.99	3,885.21	346 44 09.20	34 29 32.37	90 35 27.48
		02.70	00.00				
217	Belfor	41 47 19.55	19.26	2,794.90	131 43 24.47		
218	Williamson	74 58 51.56	52.14	2,086.06	236 43 46.10		
220	Glendale	63 13 47.88	48.60	3,023.47	353 30 36.23	*34 30 09.51	*90 34 19.11
		58.99	00.00				
218	Williamson	50 36 58.13	57.74	2,965.27	186 06 48.39		
219	Helena	44 29 02.14	02.88	2,301.00	321 37 52.51	34 31 08.06	90 35 15.09
220	Glendale	84 53 59.45	59.38	2,086.06	56 44 24.83		
		59.72	00.00				
219	Helena	92 25 53.93	53.40	2,301.01	321 37 52.51		
220	Glendale	51 25 45.88	45.15	*3,898.15	*193 04 09.38		
221	Ude	36 08 21.16	21.45	3,050.46	49 12 50.45	*34 32 12.74	*90 33 44.53
		00.97	00.00				
219	Helena	60 32 37.48	33.55	3,050.46	229 11 59.12		
221	Ude	55 19 46.98	45.61	2.951.98	104 32 36.06		
222	Cemetery	64 07 40.00	40.84	2,788.28	348 39 13.37	34 32 36.78	90 35 36.59
		04.46	00.00				
221	Ude	69 57 30.81	30.91	2,951.98	104 32 36.06		
222	Cemetery	64 36 58.44	56.38	3,893.11	219 54 36.15		
223	Adams	45 25 28.12	32.71	3,743.95	354 29 59.00	34 34 13.68	90 33 58.61
		57.37	00.00				
221	Ude	30 17 57.91	51.40	3,743.95	174 30 06.97		
223	Adams	103 07 53.85	55.11	2,600.85	251 22 03.89		
224	Helena, Island No. 2	46 34 07.92	13.49	5,020.58	24 48 45.27	34 34 40.65	90 32 21.91
		59.68	00.00				
223	Adams	46 39 58.96	40 00.30	2,600.85	251 22 03.89		
224	Helena, Island No. 2.	67 23 36.46	35.90	2,071.79	138 46 34.66		
225	Buckshot	65 56 20.42	23.80	2,629.47	24 42 28.06	34 35 31.21	90 33 15.48
		55.84	00.00				

*The length and azimuth of the line Ude-Glendale and the co-ordinates of its extremities were furnished by the United States Coast and Geodetic Survey, and are assumed as correct.

B 1.

REPORT OF ASSISTANT ENGINEER G. Y. WISNER UPON THE FINAL REDUCTION OF SECONDARY TRIANGULATION FROM HELENA ISLAND TO GREENVILLE, AND FROM GRAFTON TO CAIRO, ILL.

SAINT LOUIS, *August* 17, 1882.

SIR: I have the honor to submit herewith the least square adjustment of the triangulation of the Mississippi River from Grafton, Ill., to Cairo, Ill., and from Helena, Ark., to Greenville, Miss.

The computation has been made as follows:

1st. Least square adjustment of all quadrilaterals and pentagons.

2d. Computations of lengths and azimuths of the triangle sides and formation of equations of condition.

3d. Adjustment of the angles so that the triangles would close, the computed length of bases agree with the measured lengths, and the computed azimuths agree with the observed azimuths.

The adjustment of the triangulation from Helena to Greenville depends on the lengths and azimuths of two base lines connected by 44 quadrilaterals and 134 single triangles.

In the section from Grafton to Cairo the adjustment depends on length and azimuth of a base line at Cairo, length and azimuth of a base near Chester, Ill., length and azimuth of a Coast and Geodetic Survey line at Saint Louis, and the length of base line at Grafton. The azimuth of a line was also observed near the Grafton base, but not with sufficient accuracy to be of any value except as a check.

In any system of triangulation where the measurements of angles are made to cylindrical or octagonal targets such as were used in a large portion of the above work, an accumulation error due to phase will occur. The amount and effect of this error will depend on the direction of the system, with reference to that of illumination during the time of measurement. If the exterior lines of the triangles are parallel to the direction of illumination, or such that the light during work falls as often on the right as on the left of the system, the errors in the angles affecting the computed azimuths will be compensating, but the error in the angles opposite the transverse sides will, in any triangle, generally have contrary signs, making an accumulative error in the computed lengths of lines.

If the direction of the illumination be at right angles to the system, the errors in the angles between the exterior lines on one side of the system will be positive and on the other side negative, causing an accumulative error in the computed azimuths, while the errors in the angles affecting the computed distances will be compensating. The general direction of the river from Helena to Greenville is west of south, or such that the illumination would be on the east side of the system of triangulation during more than half the time of observations.

The effect of phase in this section would be to curve the measured system to the eastward of its true position and make the length of the computed sides from Helena to Greenville less than the correct distances. The reduction of the observations shows this to be the case; the accumulative error in 219 triangles being $26''.6$ in azimuth and 1: 30,000 in computed distance.

From Cairo to Chester the general direction of the work is about northwest, making the illumination on the west side of the system for the greater portion of the time of observation.

In this section of only 39 triangles the azimuth error amounts to $21''.8$, and the accumulated error in the computed length of sides is 1: 6000.

From Chester the general direction of the work is northwest for about one-half the distance to Saint Louis, and then bears to the east of north.

The observations being made mostly in the morning and evening, the average direction of the illumination was nearly perpendicular to sides of the system, and consequently the phase error did not materially affect the computed lengths of sides, but as nearly two-thirds of the angles were measured with the illumination to the westward, the effect on the computed azimuths amounted to $0''.4$ for each triangle.

In the section from Saint Louis to Grafton the general direction is east of north for about one-half the distance, and then for remainder of section is nearly west. The effect of phase is partially eliminated by change of direction and amounts to only 1: 30,000 for 35 triangles.

If the diameters of the targets used at the different stations and the character of the weather at the time each angle was read were known, a series of corrections could be computed which, when applied, would probably give a close agreement between the computed and measured lengths of bases. These elements being unknown, each angle has been given equal weight in the equations of condition, and the corrections to the angles necessary to make the work consistent computed by method of least squares.

The following table shows the amount of discrepancy in the computed and measured length of bases and computed and observed azimuths:

Section.	No. of triangles.	Error in computed distance.	Error in computed azimuth.
Grafton-Saint Louis	35	1 : 30000	3″.0*
Saint Louis-Chester	23	1 : 100000	9″.3
Chester-Cairo	39	1 : 6000	21″.8
Adams-Helena	4	1 : 5700	17″.0
Helena-Greenville	219	1 : 1000	26″.6
Helena-Concordia	87	1 : 1100	.....
Greenville-Saint Anderson	33	1 : 15000	.....
Greenville-Prentiss	93	1 : 13000	.....

*Approximate.

The comparisons at Concordia, Prentiss, and Port Anderson are with sides of triangles which were carefully measured with a chain the length of which was determined by a similar measurement of the Greenville base line.

The large discrepancy between the measured base at Helena and its length computed from the line Adams–Buckshot, indicates an error in the connection with the latter line.

The length of the line is derived from the base line at Harbert's Point, which checks with the base at Memphis to within 1: 25000 in distance and 2″.4 in azimuth. As the work below Harbert's Point was done by the same party as that above, it is very improbable that the accumulation took place in this work; and as it is also improbable that an error of 17″.0 could accumulate in the four triangles connecting this line with the work at Helena, the result indicates that an error was made in connecting with the station at Adams or Buckshot.

The comparisons with the measured sides of triangle at Concordia and Prentiss show that a larger portion of the accumulated error is in the work above the latter place. This result was expected from the very different methods adopted by the observers in doing the work in the two sections. From Helena to Prentiss, with a few exceptions, only a single series of triangles was observed, the angles being measured between octagonal targets, of which the diameters were from 2 to 3 inches.

From Prentiss to Greenville a quadrilateral system was observed. Octagonal targets one inch in diameter were used on the shorter lines, where their distinctness made the probability small of any error occurring from phase, and on the longer lines flat targets were used. In distributing the error between these two sections it has been assumed that since the error due to phase is proportional to the diameters of the targets used, and since the quadrilateral adjustments of the lower section make its weight nearly twice that of the upper section, the relative accuracy of the results in the two sections would have as great a ratio as 1 : 4. Since the amount of error due to phase in each section depends on the number of triangles and the respective direction of the sections with reference to the illumination during work, the error for the lower section would be about five-ninths that of the upper for similar work; but as flat targets were used on at least one-third the line of lower section, this estimate is probably large.

This distribution places one-ninth of the total error in the section from Prentiss to Greenville, making the accumulated error 1 : 10000 for 93 triangles. After adjustment the measured and computed length of line at Prentiss agree to within 1 : 44000.

The astronomical latitudes and longitudes of Helena and Greenville, compared by using the adjusted angles in the computation of geodetic positions, differ by 1″.3 in latitude and 1″.6 in longitude—differences less than the local error of astronomical determinations due to deviations of plumb-line from the normal.

The latitudes and longitudes of the stations between Cairo and Grafton have not as yet been computed, only so far as necessary for forming azimuth equations for making adjustment of angles. It is unfortunate that the computation of the geodetic positions of the stations of the Mississippi River triangulation has been made in so many different sections, as the local errors of the astronomical observations for the different sections give two sets of values for the latitude and longitude of those stations where the work is connected.

If a mean latitude and longitude had been adopted for the whole work, the computed positions would have been nearer the truth than those obtained from the mean astronomical values for each section, and the results would have been consistent throughout.

The mean latitude and longitude for the reduction of the triangulation above Cairo

should not be adopted until the work is completed, as the local errors of the astronomical determinations in this work will probably be much larger than those in the work on the lower river.

Very respectfully submitted.

GEO. Y. WISNER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

APPENDIX C.

REPORT OF ASSISTANT ENGINEER J. B. JOHNSON UPON PRECISE LEVELING OPERATIONS BETWEEN FRIAR'S POINT AND GREENVILLE, MISS., 1880–'81.

OFFICE MISSISSIPPI RIVER COMMISSION,
St. Louis, Mo., December 4, 1882.

SIR: I have the honor to submit the following résumé of the precise leveling operations from Friar's Point, Miss., to Greenville, Miss., for the years 1880 and 1881:

The work was done in two sections—

1. Friar's Point to Prentiss, a distance of 88 miles by river, under Assistant J. A. Paige.

2. Prentiss to Greenville, a distance of 80 miles by river, under Assistant J. B. Johnson.

1. FRIAR'S POINT TO PRENTISS.

This was a continuation of the season's work from Columbus, Tenn., to Memphis, Tenn., being done by the same party, instruments, and methods. The methods of reduction were also the same. The latter work was fully described in the report of the Mississippi River Commission of November 25, 1881 (Appendix C), printed in Senate ex. doc. No. 10, Forty-seventh Congress, first session. The same instrumental constants were used here as are given in that report.

The field season extended from April 26, 1880, when the quarter-boat was ready to leave Memphis, to July 6, when it was laid up at Hampton Landing. One-half the party, under Assistant B. D. Frost, was engaged till May 29 in completing the work from Columbus to Memphis, portions of which had been left on account of the high water.

It is only necessary here, therefore, to give a summary of the results, together with an analytical table of details.

RESULTS.

Distance by river	miles..	88
Length of line run (114 kilometers)	do....	71
Whole time employed, single party	days..	33
Whole time employed, double party	do....	39
Equivalent time for single party	do....	111

Five days for the double party was spent in awaiting a tow-boat at the close of the season. The actual working season, aside from time spent in getting to and from work and in determining constants, was—

For single party	days..	30
For double party	do....	25
Equivalent time for single party	do....	80
Average daily progress for actual working season for single party (1.42 kilometers)	miles..	0.9
Probable error of mean elevations for whole line	millimeters..	13.4
Probable error of mean per kilometer	do....	1.25

Of the 65 stretches, or sections, in the office computation, 19 were run both north and south.

The total length of the line run in both directions is 32 kilometers, or 28 per cent. of the entire line. Of these 19 stretches run in opposite directions, 9 of them have the south line, giving higher elevations than the corresponding north lines; 9 have the south line, giving lower elevations than the north line, while on one stretch there was no difference. The total difference between the sum of the 19 south elevations and the corresponding north elevations is 4.0^{mm}.

It is evident, therefore, that there is no reason to infer from the work itself tha

there was any constant error resulting from, or dependent upon, the direction in which the line was run.

All results that have been used have been given equal weight. Two results were rejected; they are given in the table and are marked "rejected."

The method of finding the probable error is described in the published report above referred to. In the table the probable error r is given for each stretch, and for each permanent bench the probable error R is given for the mean elevation of that point as computed from the initial bench at Friar's Point.

2. PRENTISS TO GREENVILLE.

This work was done by a single party composed of J. B. Johnson, assistant engineer in charge, E. H. Sankee, recorder, 2 rodmen, 1 cook, and 4 boatmen.

The party was quartered on the United States Survey boat Pioneer. This boat was floated from Hampton Landing, Ark., to Prentiss, Miss., a distance of 181 miles, from October 31 to November 7, 1880.

The instrumental outfit included Kern levels Nos. 3 and 4, and Kern rods Nos. 14 and 15.

The constants of these instruments had never been determined, and the rods had only been approximately compared with a standard meter in the office.

Three days were spent in determining the instrumental constants of level No. 3, in comparing the rods, and in making the necessary tables of reduction.

The actual leveling was begun on November 11, 1880, and the line was completed at Greenville on January 21, 1881, being a distance of 45 miles. This occupied a total period of 72 days. One day was spent in again comparing the rods at Greenville. On January 24 the Pioneer was taken in tow by the steamer John Dippold and towed up the river to Hampton Landing, arriving there on January 28. Here the party was disbanded.

METHODS.

All methods of observation, reduction and determining of constants were essentially the same as those given in the report of Chief of Engineers for 1880, p. 2426. Care was taken, however, to duplicate all lines in the opposite direction. When four lines were run over the same stretch, two were run south and two north.

For the first 29 miles of the line, the rods rested on foot plates. For the remaining 16 miles, which was mostly over a levee two years old, the rods rested on stakes.

RESULTS.

Total length of line run	miles..	45
Actual field season aside from time spent in getting to and from work and determining constants was	days..	72
Leveling operations were actually performed, however, on but	do..	37

Average daily progress for actual field season 1 kilometer, or five-eighths of a mile.

For a large portion of the season the weather was either rainy or clear and frosty, conditions equally bad for this work.

During the season there was 173 kilometers of single line run (107 miles); this would be an average of 4.7 kilometers (2.9 miles) of single line for every day on which work could be done.

	Millimeters.
Probable error of mean elevations for the whole line	7.4
Probable error of mean per kilometer	0.87

All determinations were used and given equal weight.

EXPLANATION OF TABLES.

In the following tables of results—

Column 1 gives the bench mark "T. B. M.," signifying temporary bench mark, and "P. B. M.," signifying permanent bench mark.

Column 2 contains the distances in kilometers from the initial bench mark at Friar's Point.

Column 3 gives the direction in which the line was run; S. for south and N. for north.

Column 4 gives the successive differences of elevation between benches and the mean of all such determinations.

Column 5 gives the residuals found by subtracting each determination from the mean.

Column 6 contains the probable error r, for the several stretches.

Column 7 gives the probable error R, of the mean elevation of each permanent bench mark as computed from the initial benches at Friar's Point.

Column 8 contains the elevations of all benches referred to the "Cairo datum," which is 290.84 feet below the zero of the United States engineer's gauge at Cairo, Ills.

Column 9 contains the rod corrections which are to be applied to the elevations in column 8. This quantity is uniform in table II, because there was no rod correction for that part of the work.

Column 10 contains the corrected elevations referred to the above datum plane.

Column 11 contains the initial of the observer for each determination in table I. Since there was but one observer in the work from Prentiss to Greenville this column was not needed in table II.

"P" is for Assistant J. A. Paige.
"F" is for Assistant B. D. Frost.
"S" is for Recorder E. H. Sankee.

It will be noted that the distances, probable errors, rod corrections, and elevations are continuous through both tables.

Very respectfully, your obedient servant,

J. B. JOHNSON,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

CONSTANTS FOR KERN LEVEL NO. 3, AND KERN LEVEL RODS XIV AND XV.

[*p* is for "pivot correction" or correction for inequality of telescope rings. It is the angular correction to be applied to the line of collimation to reduce it to the horizontal plane of the upper surface of the rings. *v* is for value of one division of the bubble-tube in seconds of arc. L is length of a three-meter rod.]

Date.	Constant.	No. of observations.	Probable error.	Method.	Remarks.
			″		
Nov. 8, 1880	$p = +3.38$	10	0.04	Instrument on stump	
8, 1880	$v = 3.31$	13	0.04	By rod at 100^m	Cold.
9, 1880	$v = 2.89$	32	0.03	By rod at 30^m to 100^m	Warm.
Feb. 15, 1881	$v = 3.28$	18	0.03	By rod at 50^m to 100^m	Cold.
Apr. 5, 1881	$v = 2.90$	10	0.01	By theodolite	Warm.
11, 1881	$v = 2.94$	10	0.02	By do	Do.
11, 1881	$v = 3.08$	10	0.02	By rod at 70^m	Do.
Mean.	$v = 3.07$	.....	.....	(*)	
Apr. 21, 1881	L = 2^m.99987	.....	.....		

* Rods XIV and XV both compared with Rod XIII, which had been compared with standard meter at Lake Survey Office at Detroit. Both the same length within 0.1 millimeter.

NOTE.—The bubble evidently changed its value for temperature, owing to the method of fastening in the case. It is thought the mean temperature of the above six observations fairly represents the mean temperature of the season, and therefore the mean value, 3″.07, was used for the final reductions.

TABLE I.—*Results of precise leveling.*

FRIAR'S POINT TO PRENTISS, MISS.

Bench.	Distance.	Direction.	Difference of elevation.	V.	*r.*	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M., Friar's Point, II.	0.0	.....	.....	.....	.....	.....	61.2991	.....	*61.2991	
T. B. M. 350.....	0.380	S	—1.3567	—0.5	0.4	.....	59.9419	.....	.....	Paige.
		S	—1.3578	+0.6	.....	.....	.....	.....	.....	Do.
		Mean ..	—1.3572							
T. B. M. 355.....	0.73	S	+0.9971	—2.8	1.9	.....	60.9392	.....	.....	Do.
		S	+0.9915	+2.8	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.9943							
T. B. M. 356.....	4.40	S	—0.0429	—5.7	2.1	.....	60.8876	.....	.....	Do.
		S	—0.0494	+0.8	.....	.....	.....	.....	.....	Do.
		S	—0.0534	+4.8	.....	.....	.....	.....	.....	Do.
		Mean ..	—0.0486							
T. B. M. 357.....	5.41	S	+0.2204	+1.0	0.6	.....	61.1090	.....	.....	Do.
		S	+0.2223	—0.9	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.2214							
T. B. M. 358.....	6.29	S	—0.3139	+0.9	1.4	.....	60.7960	.....	.....	Do.
		S	—0.3159	+2.9	.....	.....	.....	.....	.....	Do.
		S	—0.3091	+3.9	.....	.....	.....	.....	.....	Do.
		Mean ..	—0.3130							
T. B. M. 360.....	7.16	S	+0.0790	+4.4	2.9	.....	60.8794	.....	.....	Do.
		S	+0.0877	—4.3	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.0834							
T. B. M. 367.....	11.55	S	—0.7324	—1.2	0.8	.....	60.1458	.....	.....	Do.
		S	—0.7347	+1.1	.....	.....	.....	.....	.....	Do.
		Mean ..	—0.7336							
P. B. M. 57.....	15.72	S	—1.8357	—0.1	0.0	4.4	58.3100	+0.4	58.3104	Do.
		S	—1.8358	—0.0	.....	.....	.....	.....	.....	Do.
		Mean ..	—1.8358							
T. B. M. 375.....	17.08	S	+0.0740	—2.4	1.6	.....	58.3816	.....	.....	Do.
		S	+0.0693	+2.3	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.0716							
T. B. M. 378.....	18.87	S	+1.1445	+4.1	2.7	.....	59.5302	.....	.....	Do.
		N	+1.1526	—4.0	.....	.....	.....	.....	.....	Do.
		Mean ..	+1.1486							
T. B. M. 379.....	20.01	S	+0.3284	—3.0	2.0	.....	59.8556	.....	.....	Do.
		N	+0.3225	+2.9	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.3254							
T. B. M. 381.....	20.99	S	—0.3477	+1.5	1.0	.....	59.5094	.....	.....	Sankee.
		N	—0.3448	—1.4	.....	.....	.....	.....	.....	Paige.
		Mean ..	—0.3462							

*Elevation of Friar's Point II (from Report of Chief of Engineers for 1879) = 57.2970, referred to Memphis datum; elevation of Friar's Point II (from M. R. C. precise level) = 61.2991 referred to Cairo datum.

Results of precise leveling—Friar's Point to Prentiss, Miss.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	*r.*	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M. 58.....	21.80	S	−1.1012	−3.2	1.2	6.0	58.4050	+0.4	58.4054	Sankee.
		N	−1.1045	+0.1	.....	.....	.....	.....	.....	Paige.
		N	−1.1075	+3.1	.....	.....	.....	.....	.....	Sankee.
		Mean ..	−1.1044							
T. B. M. 384.....	24.30	S	+0.6077	−0.8	0.5	.....	59.0119	.....	.....	Do.
		N	+0.6061	+0.8	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.6069							
T. B. M. 388	26.69	S.....	+0.2780	−1.6	1.1	.....	59.2883	.....	.....	Do.
		N	+0.2748	+1.6	.....	.....	.....	.....	.....	Do.
		Mean ..	+0.2764							
P. B. M. 59.....	28.97	S.....	−0.1866	−3.4	2.2	6.5	59.0983	+0.3	59.0986	Do.
		N.....	−0.1933	+3.3	.....	.....	.....	.....	.....	Do.
		Mean ..	−0.1900							
T. B. M. 396	31.14	S	−0.8017	−3.0	2.0	.....	58.2936	.....	.....	Do.
		N.....	−0.8077	+3.0	.....	.....	.....	.....	.....	Do.
		Mean ..	−0.8047							
△State levee.....	32.01	S	+1.1899	+2.9	2.0	7.1	59.4864	+0.2	59.4866	Paige.
		N.....	+1.1958	−3.0	.....	.....	.....	.....	.....	Do.
		Mean ..	+1.1928							
T. B. M. 401	34.12	S.....	−0.4296	−4.0	2.6	.....	59.0528	.....	.....	Sankee.
		N.....	−0.4375	+3.9	.....	.....	.....	.....	.....	Do.
		Mean ..	−0.4336							
T. B. M. 404.....	35.92	S.....	−1.2825	+10.5	3.7	.....	57.7808	.....	.....	Paige.
		S	−1.2643	−7.7	.....	.....	.....	.....	.....	Sankee.
		S	−1.2692	−2.8	.....	.....	.....	.....	.....	Do.
		Mean .	−1.2720							
P. B. M. 60	37.82	S	−0.3742	+7.9	2.7	8.8	57.4145	+0.5	57.4150	Paige.
		S.....	−0.3637	−2.6	.....	.....	.....	.....	.....	Sankee
		S	−0.3609	−5.4	.....	.....	.....	.....	.....	Do.
		Mean ..	−0.3663							
△Richardson	38.60	S.....	+0.2716	+0.8	0.5	8.8	57.6869	+0.4	57.6873	Paige.
		S.....	+0.2732	−0.8	.....	.....	.....	.....	.....	Sankee.
		Mean ..	+0.2724							
T. B. M. 409	40.16	S.....	−1.3069	+5.6	3.7	.....	56.3856	.....	.....	Paige.
		N.....	−1.2957	−5.6	.....	.....	.....	.....	.....	Do.
		Mean ..	−1.3013							
T. B. M. 412	42.26	S.....	−0.6312	−5.0	3.3	.....	55.7494	.....	.....	Sankee.
		N.....	−0.6413	+5.1	.....	.....	.....	.....	.....	Paige.
		Mean ..	−0.6362							
P. B. M. 61.....	45.30	S.....	−0.3277	−0.6	0.4	10.1	55.4211	+0.7	55.4218	Do.
		S.....	−0.3289	+0.6	.....	.....	.....	.....	.....	Do.
		Mean ..	−0.3283							
T. B. M. 419	49.24	S	+1.0150	+0.6	0.4	.....	56.4367	.....	.....	Paige.
		S	+1.0162	−0.6	.....	.....	.....	.....	.....	Do.
		Mean ..	+1.0156							

Results of precise leveling—Friar's Point to Prentiss, Miss.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	*r.*	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M. 62	50.24	S	+0.1255	+1.1	0.7	10.1	56.5633	+0.6	56.5639	Do.
		N	+0.1276	−1.0						Do.
		Mean	+0.1266							
T. B. M. 423	52.24	S	−0.9064	+0.6	0.4		55.6575			Sankes.
		N	−0.9052	−0.6						Do.
		Mean	−0.9058							
T. B. M. 425	53.85	S	−0.7052	+1.8	1.2		54.9541			Do.
		N	−0.7016	−1.8						Do.
		Mean	−0.7034							
T. B. M. 429	56.43	S	+0.1683	−2.3	1.5		55.1201			Do.
		N	+0.1637	+2.3						Do.
		Mean	+0.1660							
P. B. M. 63	58.05	S	+0.3461	−2.3	1.5	10.4	55.4639	+0.7	55.4646	Frost.
		S	+0.3416	+2.2						Do.
		Mean	+0.3438							
T. B. M. 432	59.24	S	+0.5999	−0.7	0.4		56.0631			Do.
		S	+0.5986	+0.6						Do.
		Mean	+0.5992							
T. B. M. 434	61.13	S	−0.0502	+1.4	0.9		56.0143			Do.
		S	−0.0475	−1.3						Do.
		Mean	−0.0488							
T. B. M. 438	64.21	S	+0.2446	−0.3	0.2		56.2586			Do.
		S	+0.2440	+0.3						Paige.
		Mean	+0.2443							
T. B. M. 440	66.53	S	−0.4783	−0.9	0.6		55.7794			Do.
		S	−0.4800	+0.8						Frost.
		Mean	−0.4792							
T. B. M. 442	67.53	S	−1.8886	−2.4	1.4		53.8884			Do.
		S	−1.8951	+4.1						Paige.
		N.	−1.8894	−1.6						Do.
		Mean	−1.8910							
P. B. M. 64	70.60	S	+1.3409	−2.7	1.8	10.8	55.2266	+0.8	55.2274	Frost.
		S	+1.3356	+2.6						Paige.
		Mean	+1.3382							
T. B. M. 446	71.60	S	+0.5867	+1.0	0.7		55.8143			Frost.
		S	+0.5887	−1.0						Paige.
		Mean	+0.5877							
P. B. M. 65	72.15	S	−1.5212	+0.7	1.7	10.9	54.2938	+0.9	54.2947	Frost.
		S	−1.5159	−4.6						Paige.
		S	−1.5243	+3.8						Do.
		Mean	−1.5205							
T. B. M. 448	73.18	S	+0.7921	−2.7	1.5		55.0832			Frost.
		S	+0.7911	−1.7						Paige.
		S	+0.7851	+4.3						Do.
		Mean	+0.7894							

Results of precise leveling—Friar's Point to Prentiss, Miss.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	*r.*	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 450	75.53	S	—0.6756	+2.5	1.7		54.4101			Do.
		S	—0.6706	—2.5						Frost.
		Mean	—0.6731							
T. B. M. 452	77.62	S	+0.0882	—4.1	1.4		54.4942			Do.
		S	+0.0823	+1.8						Paige.
		S	+0.0819	+2.2						Frost.
		Mean	+0.0841							
T. B. M. 454	78.69	S	+0.2369	+3.5	1.3		54.7346			Do.
		N	+0.2435	—3.1						Do.
		S	+0.2409	—0.5						Do.
		Mean	+0.2404							
T. B. M. 456	79.34	S	—0.4208	+2.7	1.8		54.3165			Paige.
		S	—0.4154	—2.7						Frost.
		Mean	—0.4181							
T. B. M. 457	80.24	S	—0.7479	—3.9	2.6		53.5647			Paige.
		S	—0.7558	+4.0						Frost.
		Mean	—0.7518							
T. B. M. 459	82.12	S	+1.3476	+5.4	3.6		54.9177			Paige.
		S	+1.3585	—5.5						Frost.
		Mean	+1.3530							
P. B. M. 66	84.76	S	—1.6382	+3.2	2.2	12.5	53.2827	+1.0	53.2837	Paige.
		S	—1.6317	—3.3						Frost.
		Mean	—1.6350							
T. B. M. 464	87.55	S	—0.5786	—2.8	1.8		52.7013			Paige.
		S	—0.5841	+2.7						Frost.
		Mean	—0.5814							
P. B. M. 67	89.66	S	+0.6266	—1.4	0.9	12.7	53.3265	+1.0	53.3275	Do.
		S	+0.6239	+1.3						Paige.
		Mean	+0.6252							
T. B. M. 469	91.40	S	—0.5544	—2.0	1.4		52.7701			Do.
		S	—0.5585	+2.1						Frost.
		Mean	—0.5564							
T. B. M. 471	93.50	S	—0.2187	+3.4	2.3		52.5548			Paige.
		S	—0.2119	—3.4						Frost.
		Mean	—0.2153							
P. B. M. 68	95.27	S	—1.7081	—1.2	0.8	13.0	50.8455	+1.3	50.8468	Paige.
		S	—1.7105	+1.2						Frost.
		Mean	—1.7093							
P. B. M. 69	96.09	S	+1.4033	+1.5	1.0	13.0	52.2503	+1.1	52.2514	Paige.
		S	+1.4063	—1.5						Frost.
		Mean	+1.4048							
T. B. M. 474	97.06	S	+0.3971	—0.7	0.4		52.6467			Do.
		S	+0.3958	+0.6						Paige.
		Mean	+0.3964							

Results of precise leveling—Friar's Point to Prentiss, Miss.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M. 70	98.53	S	−0.7526	+0.5	1.4	13.0	51.8946	+1.2	51.8958	Do.
		S	−0.7484	−3.7						Frost.
		S	−0.7554	+3.3						Do.
		Mean	−0.7521							
T. B. M. 478	100.73	S	+1.2629	+2.7	1.8		53.1602			Paige.
		S	+1.2682	−2.6						Frost.
		Mean	+1.2656							
T. B. M. 481	102.78	S	−1.2154	−2.8	1.9		51.9420			Do.
		S	−1.2210	+2.8						Paige.
		Mean	−1.2182							
T. B. M. 482	103.56	S	−0.9581	+2.3	0.8		50.9862			Do.
		S	−0.9553	−0.5						Frost.
		S	−0.9442*							Do.
		S	−0.9539	−1.9						Do.
		Mean	−0.9558							
T. B. M. 483	104.64	S	−0.1068	−1.4	0.9		50.8780			Do.
		S	−0.1095	+1.3						Paige.
		Mean	−0.1082							
T. B. M. 485	105.64	S	+0.1900	+2.3	1.2		51.0703			Do.
		S	+0.1954	−3.1						Frost.
		S	+0.1914	+0.9						Do.
		Mean	+0.1923							
P. B. M. 71	107.64	S	−0.4682*			13.4	50.6179	+1.3	50.6192	Paige.
		S	−0.4524							Do.
		N	−0.4524							Frost.
		Mean	−0.4524							
T. B. M. 492	110.96	S	−0.0625	+1.1	0.7		50.5565			Paige.
		S	−0.0604	−1.0						Frost.
		Mean	−0.0614							
P. B. M. 72	111.92	S	+0.7277	−4.2	1.5	13.5	51.2800	+1.3	51.2813	Do.
		S	+0.7199	+3.6						Paige.
		S	+0.7230	+0.5						Frost.
		Mean	+0.7235							
T. B. M. 496	113.76	S	−0.6917	+1.5	1.0		50.5898			Paige.
		S	−0.6887	−1.5						Frost.
		Mean	−0.6902							
T. B. M. 497	113.78	S	−0.4836	+0.4	0.2		50.1066			Paige.
		S	−0.4829	−0.3						Frost.
		Mean	−0.4832							
P. B. M. 74	113.88	S	+0.6915	−0.1	0.1	13.6	51.2812	+1.3	51.2825	Paige.
		S	+0.6912	+0.2						Frost.
		Mean	+0.6914							
P. B. M. 75	113.98	S	+0.8058	+0.4	0.2	13.6	51.3960	+1.2	51.3972	Paige.
		S	+0.8065	−0.3						Frost.
		Mean	+0.8062							
P. B. M. 73	114.05	S	−0.4920	−0.4	0.2	13.6	50.7888	+1.3	50.7901	Paige.
		S	−0.4927	+0.3						Frost.
		Mean	−0.4924							

* Rejected.

TABLE II.—*Results of precise leveling.*

PRENTISS TO GREENVILLE, MISS.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M. 73	114.05				0.2	13.6	50.7888	+1 3	50.7901	
P. B. M's. 73, 74 and 75. Mean.		S	+0.3627	+0.1	0.1	13.6	51.1516	+1.3	51.1529	
		N	+0.3629	−0.1						
		Mean	+0.3628							
T. B. M's 498 and 499.	116.68	S	−1.2251	−2.1	1.4		49.9244			
		N	−1.2292	+2.0						
		Mean	−1.2272							
T. B. M's 500 and 501.	120.14	S.	−0.2365	−4.2	1.6		49.6837			
		N	−0.2449	+4.2						
		N	−0.2406	−0.1						
		Mean	−0.2407							
P. B. M. 76	121.58	S	+0.6659	+1.9	1.3	13.8	50.3515	+1.3	50.3528	
		N	+0.6697	−1.9						
		Mean	+0.6678							
T. B. M. 502	122.67	S	−1.2529	+0.1	0.1		49.0987			
		N	−1 2526	− 0.2						
		Mean	−1.2528							
T. B. M's 504 and 505.	123.67	S	+0.6142	+0.4	0.2		49.7133			
		N	+0.6149	−0.3						
		Mean	+0.6146							
T. B. M's 506 and 507.	124 86	S	−0.8278	−2.0	1.4		48.8835			
		N.	−0.8319	+2.1						
		Mean	−0.8298							
P. B. M. 77	125.38	S	+0.4867	+0.9	0.6	13 9	49.3711	+1.3	49.3724	
		N	+0.4886	−1.0						
		Mean	+0.4876							
T. B. M's 508 and 509.	128.83	S	−0.3860	−1.2	1.2		48.9839			
		S	−0.3848	−2 4						
		N	−0.3907	+ 3.5						
		Mean	−0.3872							
P. B. M. 78	128.88					14.0	49.0026	+1.3	49.0039	
T. B. M. 510	131.44	S	−0.5026	−7.3	3.3		48.4740			
		S	−0.5077	−2.2						
		N	−0.5193	+9.4						
		Mean	−0.5099							
P. B. M. 79	131.93	S	+0.7768	−0.5	0.3	14.3	49.2503	+1.3	49.2516	
		N	+0.7758	+0.5						
		Mean	+0.7763							
T. B. M. 511	136.47	S	+0.2767	−0.1	0.1		49, 5269			
		N	+0.2764	+0.2						
		Mean	+0.2766							
P. B. M. 80	136.57					14.3	49.6868	+1.3	49.6881	
T. B. M's 512 and 513.	138.34	S	−1.0668	+2.0	−1.3		48.4621			
		N	−1.0629	−1.9						
		Mean	−1.0648							

Results of precise leveling—Prentiss to Greenville, Miss.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
P. B. M. 81	140. 98	S	+0. 3609	−2. 7	2. 1	14. 6	48. 8203	+1. 3	48. 8216	
		N	+0. 3660	−7. 8						
		S	+0. 3526	+5. 6						
		N	+0. 3534	+4. 8						
		Mean	+0. 3582							
T B. M's 514 and 515.	143. 10	S	−1. 8263	+0. 1	0. 1		46. 9941			
		N	−1. 8260	−0. 3						
		Mean	−1. 8262	−0. 3						
P. B. M. 82	145. 68	S	+1. 3815	−1. 3	0. 9	14. 6	48. 3743	+1. 3	48. 3756	
		N	+1. 3788	+1. 4						
		Mean	+1. 3802							
T. B. M. 517	149. 06	S	−0. 7897	−1. 7	1. 1		47. 5829			
		N	−0. 7931	+1. 7						
		Mean	−0. 7914							
P. B. M. 83	149, 94	S	+0. 8596	−0. 2	0. 1	14. 6	48. 4423	+1. 3	48. 4436	
		N	+0. 8592	+0. 2						
		Mean	+0. 8594							
T. B. M's 518 and 519.	150. 19	S	−0. 2204	−1. 5	0. 5		48. 2204			
		N	−0. 2217	−0. 2						
		S	−0. 2237	+1. 8						
		N	−0. 2219	0. 0						
		Mean	−0. 2219							
T. B. M's 520 and 521.	152. 03	S	+0. 1993	−1. 0	0. 7		48. 4187			
		N	+0. 1973	+1. 0						
		Mean	+0. 1983							
P. B. M. 84	152. 51	S	−0. 0202	+0. 8	0. 5	14. 7	48. 3993	+1. 3	48. 4006	
		N	−0. 0187	−0. 7						
		Mean	−0. 0194							
T. B. M. 523 and 524.	156. 62	S	−1. 6184	−3 1	2. 1		46. 7778			
		N	−1. 6246	+3. 1						
		Mean	−1. 6215							
P. B. M, 85	158. 16	S	+0. 9840	+1. 5	1. 0	14. 8	47. 7633	+1. 3	47. 7646	
		N	+0. 9870	−1. 5						
		Mean	+0. 9855							
T. B. M's 526 and 527.	159. 99	S	+1. 2473	−4. 3	1. 1		49. 0063			
		N	+1. 2392	+3. 8						
		S	+1. 2436	−0. 6						
		N	+1. 2418	+1. 2						
		Mean	+1. 2430							
P. B. M. 86	160. 25	S	−1. 7206	+0. 5	0. 3	14. 9	47. 2862	+1. 3	47. 2875	
		N	−1. 7196	−0. 5						
		Mean	−1. 7201							
T. B. M's 528 and 529.	162. 98	S	−0. 4896	−0. 4	0. 2		46. 7962			
		N	−0. 4903	+0. 3						
		Mean	−0. 4900							

Results of precise leveling—Prentiss to Greenville, Miss.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	*r.*	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 530	166.52	S	−0.8079	+2.5	1.7		45.9908			
		N	−0.8029	−2.5						
		Mean	−0.8054							
T. B. M's 531 and 532.	170.60	S	−0.5915	−1.7	1.1		45.3976			
		N	−0.5949	+1.7						
		Mean	−0.5932							
T. B. M. 532½	171.39	S	+0.6839	+0.1	0.1		46.0816			
		N	+0.6841	−0.1						
		Mean	+0.6840							
T. B. M. 533	173.03	S	−0.9842	+2.2	1.5		45.0996			
		N	−0.9798	−2.2						
		Mean	−0.9820							
P. B. M. 87	173.05					15.1	45.5266	+1.3	45.5279	
T. B. M. 534	174.78	S	+2.3185	−5.0	1.2		47.4131			
		N	+2.3132	+0.3						
		S	+2.3101	+3.4						
		N	+2.3121	+1.4						
		Mean	+2.3135							
T. B. M. 535	176.25	S	−0.9495	+0.5	0.3		46.4641			
		N	−0.9485	−0.5						
		Mean	−0.9490							
T. B. M. 536	178.23	S	−2.9002	−1.2	0.8		43.5627			
		N	−2.9027	+1.3						
		Mean	−2.9014							
P. B. M. 88	179.36	S	+0.6675	+0.2	0.1	15.2	44.2304	+1.3	44.2317	
		N	+0.6679	−0.2						
		Mean	+0.6677							
T. B. M's 537 and 538.	182.81	S	+1.2836	+7.9	2.8		45.5219			
		N	+1.2982	−6.7						
		N	+1.2926	−1.1						
		Mean	+1.2915							
C. and G. S., Greenville, No 1.	184.73	S	+0.5625	+3.4	1.3	15.5	46.0878	+1.3	46.0891	
		N	+0.5693	−3.4						
		S	+0.5660	−0.1						
		Mean	+0.5659							
C. and G. S., Greenville, N'th base.	185.57	S	−1.6126	+2.1	0.9	15.5	44.4773	+1.3	44.4786	
		N	−1.6070	−3.5						
		S	−1.6123	+1.8						
		N	−1.6099	−0.6						
		Mean	−1.6105							
C. and G. S., Greenville, No. 2.	186.17	S	+2.1062	+0.6	0.4	15.5	46.5841	+1.3	46.5854	
		N	+2.1075	−0.7						
		Mean	+2.1068							

DESCRIPTION OF PERMANENT BENCH-MARKS FROM FRIAR'S POINT, MISS., TO GREENVILLE, MISS.

U. S. P. B. M. Friar's Point II. (*From Report Chief of Engineers*, 1879, *page* 19).—Is center of hole in copper bolt 1 centimeter in diameter, leaded horizontally in a brick in northeast end of southeast wall of brick building, belonging to W. H. Dickerson, at Friar's Point, Coahoma County, Mississippi. The building is in block No. 2, of Fuller's addition.

U. S. P. B. M. (57).—Is top of copper bolt in top of stone on Ledbetter's plantation, 10½ miles below Friar's Point, Mississippi, measured along the levee. It is 13 meters east of levee, 610 meters above houses on Ledbetter's plantation, and near three trees (box-elder, sycamore, and pecan).

U. S. P. B. M. (58).—Is top of copper bolt in top of stone on west slope of levee, about 800 meters above Burke's or Hughe's Landing, Coahoma County, Mississippi. It is 38 meters below bend in levee, and 23 meters above a small honey-locust on west slope of levee. Top of bolt is 2 millimeters above top of stone.

U. S. P. B. M. (59).—Is top of copper bolt in top of stone set in east slope of levee, 3¾ miles below Hughes' Landing, near Campbell's house, and 3 meters north of a sycamore tree. It is about 80 meters above junction of levees. Top of bolt is 6 millimeters above top of stone.

U. S. P. B. M. (60).—Is top of copper bolt in top of stone on east side of levee, 2½ miles above Sunflower Landing, Coahoma County, Mississippi. It is about 230 meters above deserted cabin on levee, and about 800 meters above △ Richardson.

U. S. P. B. M. (61).—Is top of copper bolt in top of stone set on east slope of levee, at Robinsonville, Coahoma County, Mississippi. Stone is about 90 meters above deserted store on east side of levee, where road from gin crosses levee.

U. S. P. B. M. (62).—Is top of copper bolt in top of stone on east slope of levee, near locust trees, about 140 meters above Simpson's store at Lake Charles Landing, Coahoma County, Mississippi.

U. S. P. B. M. (63).—Is top of copper bolt in top of stone on west slope of levee, 1,000 meters above Australia post-office, Bolivar County, Mississippi.

U. S. P. B. M. (64).—Is top of copper bolt in top of stone on east slope of levee, 446 meters above △ South Base, at Carson's, Bolivar County, Mississippi. △ South Base is at turn in levee below the post-office.

U. S. P. B. M. (65).—Is top of copper bolt in top of stone on east side of levee, near bend of levee, in Concordia, Bolivar County, Mississippi,. The stone is 177 feet below Green's store, 117 feet above Williams' store, and 79 feet from levee.

U. S. P. B. M. (66).—Is top of copper bolt in top of stone on east slope of levee, on Stoke's plantation, 7¾ miles below Concordia, Bolivar County, Mississippi. It is 150 meters below bridge crossing ditches of levee, respectively, 91 and 127 meters below houses on east side of levee, 19 meters west of fence, and 6⅜ meters south of elm tree.

U. S. P. B. M. (67).—Is top of copper bolt in top of stone, on east slope of levee, about 1 mile south of Terrene, Bolivar County, Mississippi. It is 120 meters north of Ben Williams' house, 106 meters south of Morris Williams' house, and 4.5 meters east of center of levee.

U. S. P. B. M. (68).—Is top of copper bolt in top of stone, in Colonel Montgomery's front yard, in Floraville (or Rosedale), Bolivar County, Mississippi. It is 4 meters north of south fence, and 1 meter east of west fence.

U. S. P. B. M. (69).—Is top of copper bolt in top of stone, on east side of levee, one-half mile below Colonel Montgomery's house, at Floraville, Bolivar County, Mississippi. It is opposite a sweet-gum tree situated on west side of levee at edge of pond, and is 65 meters below fence, above which are two houses.

U. S. P. B. M. (70).—Is top of copper bolt in top of stone, at east base of levee, 290 meters below post-office at Riverton, Bolivar County, Mississippi. It is 31 meters below a cottonwood tree on east side of levee, on which tree is T. B. M. 475.

U. S. P. M. B. (71).—Is top of copper bolt in top of stone, about three-fourths of a mile below Beulah, Bolivar County, Mississippi. It is on the lands of the Owens heirs, one-quarter of a mile above northwest corner of the "Bell" plantation, now owned by J. W. Farmer. It is 1 meter southwest of a sycamore tree, and 142 meters northeast of a house.

U. S. P. B. M. (72).—Is top of copper bolt in top of stone, set in ground 1½ meters from cottonwood tree in woods, 42 meters back from Lake Beulah, and 520 meters below Clark's Landing, Bolivar County, Mississippi.

U. S. P. B. M. (73).—Is top of copper bolt in top of stone, set in corner of fence in northwest corner of Hughes' plantation, 2 miles back from Prentiss, Bolivar County, Mississippi. It is 72 meters southeast of junction of old and new levees, 65 meters northwest of gin house, 27 meters south of southwest corner of dwelling, 12 meters south of west corner of stable.

U. S. P. B. M. (74).—Is top of copper bolt in top of stone on east slope of levee,

120 meters below junction of old and new levees, 63 meters west of gin house, and 2 miles back of Prentiss, Bolivar County, Mississippi. It is 80 meters southwest of dwelling, 60 meters southwest of stable, and about 50 meters below P. B. M. (73).

U. S. P. B. M. (75).—Is top of copper bolt in top of stone, set in east slope of levee, 220 meters south of junction of old and new levees, 2 miles back from Prentiss, Bolivar County, Mississippi. It is 117 meters southwest of gin house, and 100 meters below P. B. M. (74).

U. S. P. B. M. (76).—Is top of brass bolt in stone post, set in northwest corner of Neblitt's plantation, at Neblitt's Landing, Bolivar County, Mississippi. Stone is planted in corner of fence at the turn in levee. It is about 20 meters from levee south and east, and about 25 meters from front of house at said corner of levee. Top of bolt is 2^{mm} above top of stone. (For sketch, see note book 249, p. 46.)

U. S. P. B. M. (77).—Is top of brass bolt in top of stone post planted in rear of house owned by D. McGreevy, at Stormville (or Storms), Bolivar County, Mississippi. Stone is 80 meters back of levee and 25 meters back from front of McGreevy's store. It is just inside of fence on south side of road, and about 60 meters north of the post-office. Top of bolt is flush with top of stone. (For sketch, see note book 250, p. 44.)

U. S. P. B. M. (78).—Is top of brass bolt in stone post, set in northwest corner of lot owned by Dr. Richardson, in Bolivar, Bolivar County, Mississippi. It is 15 meters back of levee, and 12 meters north of the northwest corner of Dr. Richardson's house, 6 meters from front of office adjoining the house, 16 meters north of brick cistern in yard, and about 900 meters above Bolivar post-office. Top of bolt is 6 millimeters above top of stone. (For sketch, see note book 250, p. 34.)

U. S. P. B. M. (79).—Is top of brass bolt in stone post, planted on Major Edmonds' plantation at Buck Ridge, Bolivar County, Mississippi. It is about 60 meters back of levee, and about 50 meters northwest of Major Edmonds' house. It is on north side of garden fence near northwest corner of garden. Top of bolt is 5 millimeters above top of stone. (For sk tch see book 250, p. 24.)

U. S. P. B. M. (80).—Is top of brass bolt in stone post set on land of E. F. Miller (lessee), in northwest corner of field at intersection of road leading across the point from Content to Jenkins Landings, with levee road. Stone is about 15 meters back of levee and 18 meters east of Miller's store, at Content, Bolivar County, Mississippi. Top of bolt is 2 millimeters above top of stone. (Sketch in book 250, p. 108.)

U. S. P. B. M. (81).—Is top of brass bolt in stone post set on grounds of the Jenkins estate, at Childers, or Jenkins Landing, three-fourths of a mile above Stop Landing, Bolivar County, Mississippi. Stone is 10 meters back from levee, in southwest corner of yard, 25 meters southwest from corner of Jenkins' house, about 27 meters southwest of cistern on south side of house, 50 meters south of cistern on north side of house, and 3 meters south of large gum tree. Top of bolt is 2 millimeters above top of stone. (For sketch see note book 251, p. 20.)

U. S. P. B. M. (82).—Is top of brass bolt in top of stone post set in west corner of W. E. Ringo's yard, at Mound Place, Bolivar County, Mississippi. Stone is about 10 meters back from levee and 75 meters northeast of new store, now building, of W. E. Ringo & Co. Stone is about 27 meters west from corner of house, and about 75 meters southwest of store of Simon & Brown. Top of bolt is 6 millimeters above top of stone. (For sketch see note book 251, p. 44.)

U. S. P. B. M. (83).—Is top of brass bolt in stone post set on O. L. Shelby's plantation, near Wilkerson's Landing, Bolivar County, Mississippi. Stone is in southwest corner of yard back of Shelby's house (lately torn down), is 55 meters back of levee, which is here about 200 meters from river bank; it is 40 meters southwest of a red cedar tree, 60 meters southwest of the easterly cistern and 30 meters southwest of the westerly cistern in yard, and about 110 meters west of store at Wilkerson's Landing. A blacksmith shop is to be built just west of the site of the old Shelby house. Top of bolt is 3 millimeters above top of stone. (For sketch see note book 252, p. 14.)

U. S. P. B. M. (84).—Is top of brass bolt in stone post set on Lewis Clark's plantation, 1,400 meters below Wilkerson's Landing, Bolivar County, Mississippi. Stone is just inside of fence, 15 meters back of levee, 10 meters northwest of house of Daniel Braxton (colored), 20 meters north of woods which extend to Port Anderson, some 3 miles below. Top of bolt is 5 millimeters above top of stone. (For sketch see note book 252, p. 6.)

U. S. P. B. M (85).—Is top of brass bolt in top of stone post, set in southeast corner of yard on Thomas S. Kennedy's plantation (John Graves, lessee), at Port Anderson, Bolivar County, Mississippi. Stone is 25 meters east of a brick cistern at southeast corner of house, and 40 meters southeast of a brick cistern at northeast corner of house. It is 55 meters back from levee, and about 160 meters above an abrupt turn in levee. Top of bolt is 5 millimeters above top of stone. (For sketch, see note book 252, p. 66.)

U. S. P. B. M (86).—Is top of brass bolt in top of stone post, planted on lands of Thomas S. Kennedy (—— Martin, lessee), 300 meters above Offut's Landing, Washington County, Mississippi. The stone is in southwest corner of field, 1 meter back of old levee, 25 meters north of new levee, which marks the boundary line between

Bolivar and Washington Counties, and is therefore in Bolivar County, Mississippi. Top of bolt is 4 millimeters above top of stone. (For sketch, see note book 252, p. 96.)

U. S. P. B. M (87).—Is top of brass bolt set in top of stone, planted in corner at intersection of old and new levees, about three-fourths mile back of the river in Miller's Bend, Washington County, Mississippi. Stone is about 1½ miles below Bernard's plantation, is on east side of levee, 15½ meters southwest of oak tree 2 feet in diameter, and 18½ meters northwest of gum tree 2½ feet in diameter, on which is T. B. M., 533. Both of these trees are marked by five notches. Top of bolt is 5 millimeters above top of stone. (For sketch, see note book 253, p. 66.)

U. S. P. B. M (88).—Is top of brass bolt in top of stone post, set in southwest corner of field on lands of James Rogers (colored), about 1 mile north of Argyle, Washington County, Mississippi. Stone is in corner of fence at crossing of new levee and Arkansas City road. The Memphis and Greenville telegraph line here leaves the levee and follows the Arkansas City road. Top of bolt is 3 millimeters above top of stone. (For sketch, see note book 254, p. 18.)

C. & G. S. P. B. M. (1), Greenville. (*From MS. furnished by the Coast and Geodetic Survey.*)—Is on the corrugated iron door-sill of a brick building in Greenville, known as the Bank Building. It is said to be one of the oldest brick buildings in town; the levee board has its rooms in this building, over the bank. The exact point is near the back side and west end of sill, 320 millimeters from front face, 55 millimeters from door-strip, 90 millimeters from right-hand (west) door-jamb. The door is near the northwest corner of building, in north side. The point is not marked.

C. & G. S. north base stone at Greenville.—Is top of copper bolt in large stone forming north end of the Greenville base line of the Coast and Geodetic Survey. Stone is about 100 meters south of house of M. S. Morgan, and is supposed to be on southern boundary of the city of Greenville, and on the northern line of Huntington's plantation. Top of bolt is flush with top of stone.

C. & G. S. P. B. M (2). (*From MS. furnished by the Coast and Geodetic Survey.*)—Is center of copper bolt 10 centimeters long and 2 centimeters diameter, leaded horizontally into a brick in the fourteenth tier of bricks above the water-sill of the large chimney of C. P. Huntingdon's gin-house near Greenville, Mississippi. It is on the side of the chimney facing the river. The gin-house stands about half a mile below the town and as far from the river bank. The chimney is said to be the oldest one erected for its purpose in Washington County. The letters U. S. ⊙ B. M. are cut in the brick, as here shown.

C 1.

Results of precise leveling from Cairo, Ill., to Columbus, Ky.

[Published by request of General C. B. Comstock, in charge of United States Lake Survey.]

ELEVATIONS OF BENCHMARKS AND REFERENCE POINTS AT CAIRO, ILL.

[NOTE.—The succeeding levels start with an elevation equal to 103.0005 meters on U. S. B. M. 1. According to Assistant Engineer L. L. Wheeler's levels, this B. M. is 1.1609 meters below high-water mark on the United States Engineer's gauge at Cairo. The high-water mark is 50.9 feet above the zero of the gauge, while ordinary low water intersects the gauge at 9.16 feet above the zero, making high-water mark 41.74 feet, = 12.7222 meters, above ordinary low water. The elevation for high-water mark is, therefore, 104.1614 meters, and for ordinary low water 91.4392 meters, equal to 300 feet above the datum plane of the United States Survey of the Mississippi River.]

Benchmarks.	Difference of elevation.			Elevation.	Remarks.
	First determination.	Second determination.	Mean.		
	Meters.	*Meters.*	*Meters.*	*Meters.*	
U. S. P. B. M. 1	.....	.....	.....	103.0005	
U. S. P. B. M. 2	+0.3972	+0.3980	+0.3976	103.3981	
U. S. P. B. M. 3	+2.8301	+2.8283	+2.8292	105.8297	Referred to U. S. B. M. 1.
B. M. on Donelley's mill	−1.0354	−1.0335	−1.0344	104.7953	
Reference point 1	−1.6410	−1.6401	−1.6406	104.1891	Referred to U. S. B. M. 3.
B. M. on Adler's store	+0.5727	.....	.....	104.7618	
B. M. on St. Charles hotel	+0.4034	+0.4028	+0.4031	104.5922	Referred to reference point 1.
Reference point 2	−3.3029	−3.3023	−3.3026	100.8865	Do.
Reference point 3	+0.1849 +0.1867 +0.1875 +0.1871 +0.1899	.....	+0.1872	101.0737	Mean of five results.

Reference point 3 is the first point on the Kentucky shore.

LEVELS FROM REFERENCE POINT 3 TO REFERENCE POINT 13.

Benchmarks.	Distances.	Difference of elevation.			Elevation.	Discrepancy.		Remarks.
		First determination.	Second determination	Mean.		Partial.	Total.	
	Meters	*Meters.*	*Meters.*	*Meters.*	*Meters.*	*Mm.*	*Mm*	
Reference point 3..	.....	.....	..	.....	101.0737	.... .	....	
U. S. B. M. 4.....	562	+0.1557	+0.1577	+0.1567	101.2304	−2.0	−2.0	
U. S. B. M. 5	391	+0.6348	+0.6343	+0.6346	101.8650	+0.5	−1.5	
Reference point 4..	1,457	−0.8313	−0.8307	−0.8310	100.3994	−0.6	−2.6	Referred to U. S. B. M. 4.
Reference point 5..	1,248	+0.5343	+0.5333	+0.5338	100.9332	+1.0	−1.6	
Retcrence point 6..	1,050	+0.8166	+0.8182	+0.8174	101.7506	−1.6	−3.2	
Reference point 7..	2,306	−1.6178	−1.6184	−1.6181	100.1325	+0.6	−2.6	
Reference point 8..	1,712	−2.0225	−2.0187	−2.0206	98.1119	−3.8	−6.4	
Reference point 9..	1,587	+0.2619	+0.2531	+0.2575	98.3694	+8.8	+2.4	
U. S. B. M. 6.....	968	+5.6448	+5.6409	+5.6428	104.0122	+3.9	+6.3	
Reference point 10.	1,591	−3.7716 −3.7760 −3.7775	.....	−3.7750	100.2372	*Range.* 5.9	.....	Mean of three determinations.
Reference point 11.	1,358	+0.9564 +0.9562 +0.9577	.....	+0.9568	101.1940	1.5	.....	Do.
Reference point 12.	729	−2.8836 −2.8820 −2.8843	.....	−2.8833	98.3107	2.3	.....	Do.
Reference point 13	1,320	+1.6658 +1.6655 +1.6663	.....	+1.6659	99.9766	0.8	.....	Do.

Table of results of precision.

LEVELS BETWEEN REFERENCE POINT (13) AND BENCH-MARKS AT COLUMBUS, KY.

Date.	Bench-marks.	Distance.	Difference elevations of successive bench-marks.		Elevation.		Mean elevation.	Partial difference.	Total difference.
			Rod No. 3.	Rod No. 4.	Rod No. 3.	Rod No. 4.			
		Meters	*Meters.*				*Meters.*		
	Reference Point (13)	.....	.....	.....	.....	.....	99.9766	Office report 750.	
1876.									
Dec. 27	Reference Point (14)	1,305	−0.2041						
1877.									
Jan. 2	Reference Point (14)		−0.1973						
Jan. 5	Reference Point (14)		−0.2014	−0.2004	99.7757	99.7762	99.7758	+.0010	+.0005
		Mean	[0.2009]						
Jan. 9	Reference Point (15)	1,184	+0.0591	+0.0592	99.8348	99.8354	99.8349	+.0001	+.0006
Jan. 10	Reference Point (16)	1,144	−0.5993	−0.5921					
Jan. 12	Reference Point (16)	1,151	−0 6036	−0.6021	99.2334	99.2333	99.2332	+.0015	−.0001
		Mean	[0.6014]						
Jan. 13	Reference Point (17)	386	+1.0362	+1.0359	100.2696	100.2692	100.2693	−.0003	−.0004
Jan. 17	Reference Point (18)	1,611	+1.0553	+1.0674					
Jan. 18	Reference Point (18)	1,625	+1.0534	+1.0517	101.3239	101.3209	101.3228	−.0017	−.0030
		Mean	[1.0543]						
Jan. 19	Reference Point (19)	1,351	−1.6196	−1.6218	99.7043	99.6991	99.7021	−.0022	−.0052
Jan 20	Reference Point (20)	1,409	+0.6223	+0 6244	100.3266	100.3235	100.3255	+.0021	−.0031
Jan. 22	Reference Point (21)	2,513	−0.2991	−0.2958	100.0275	100.0277	100.0280	+.0033	+.0002
Jan. 23	Reference Point (22)	716	−0.0106	−0.0101	100.0169	100.0176	100.0176	+.0005	+.0007
Jan. 23	Reference Point (23)	497	+0.2312	+0.2300	100.2481	100.2476	100, 2482	−.0012	−.0005
Jan. 24	Reference Point (24)	712	−1.3964	−1.3940	98.8517	98.8536	98.8530	+.0024	+.0019
Jan. 24	Reference Point (25)	554	−0.6155	−0.6141	98.2362	98.2395	98.2382	+.0014	+.0033
Jan. 24	Reference Point (26)	936	+3.5925	+3.5924	101.8287	101.8319	101.8307	−.0001	+.0032
Jan. 26	Reference Point (27)	1,464	+27.7949	+27.7972	129.6236	129.6291	129.6268	+.0023	+.0055
Jan. 27	Reference Point (28)	1,196	+16.8093	+16.8084	146.4329	146.4375	146.4357	−.0009	+.0046
Jan. 29	Reference Point (29)	781	−1.1116	−1.1158	145.3213	145.3217	145.3220	−.0042	+.0004
Jan. 31	Reference Point (30)	931	−2.5933	−2.5965	142.7280	142.7252	142.7271	−.0032	−.0028
Feb. 1	Reference Point (31)	626	+4.8046	+4.8025	147.5326	147.5277	147.5307	−.0021	−.0049
Feb. 2	Reference Point (32)	966	−11.2042	−11.2070	136.3284	136.3207	136.3251	−.0028	−.0077
Feb. 2	U. S. B. M. 7	971	−34.2032	−34.2017	102.1252	102.1190	102 1226	+.0015	−.0062
Feb. 3	U. S. B M. 8.....	496	−2.2079	−2.2092	99.9173	99.9098	99.9141	−.0013	−.0075
Feb. 3	U. S. B. M. 9.....	.....	+0.5382	+0.5377	100.4555	100.4475	100.4521	−.0005	−.0080
Feb. 2	Tide guage B. M....	.....	−35.2402	−35.2384	101.0882	101.0823	101.0858	+.0018	*−.0059
Feb. 2	46 ft. mark of gauge.	... ...	−35.5193	−35.5172	100.8091	100.8035	100.8069	+.0021	*−.0056

* These two points were connected with R. P. (32).

DESCRIPTION OF BENCHMARKS BETWEEN CAIRO, ILL., AND COLUMBUS, KY.

REF. PT. (15).—Highest point of spike driven into top of stump 1m. diameter; stump on S. side of road about 40m, S. E. of where road crosses small creek. Cypress tree 3m east of stump blazed. This benchmark is about 300m north of Rob. Adam's house, and about 18.8 kilometers south of point in Kentucky, opposite Cairo, Ill. Elevation, 99m.8349.

REF. PT. (16).—Top of spike in root of sycamore tree on river bank. Tree is at end of fence where road from hills comes to river bank at Puntney's Bend. Ref. Pt. (16) is on root of tree, extending down river. It is 1,144m from Ref. Pt. (15). (A check point is on root of same tree, extending toward road.) Elevation, 99m.2432. Check Pt. below Ref. Pt (16), 0m.0702.

REF. PT. (17). Highest point of spike driven into root of stump extending down stream. Stump is sycamore 0m.7 diameter, and has been broken off about 1m from ground. It is 20m east of river bank, and 70m S. W. of log shanty, which is about 400m down river from point where road from Fort Jefferson comes to river bank. Sycamore tree 8m S. E. blazed. Check Point in root of blazed tree. Ref. Pt. (17) is 386m from Ref. Pt. (16). Elevation, 100m.2693. Check Point above ref. Pt. (17) 0m.8995.

REF. PT (18).—Top of spike driven into top of locust stump 0m.2 diameter. Stump is 14m west from road, and 20m from top of river bank and between the two. It is 1611m from Ref. Pt (17). Elevation, 101m.3228.

REF. PT. (19).—Top of spike driven into top of hickory stump 0m.2 diameter; stump is 10m N. W. of Columbus road, and about 400m from river. Elm tree 1m.2 diameter, 2m S. E. of road blazed. Check Point top of spike in root of blazed tree extending away from road. It is 0m.4164 below Ref. Pt. (19). Distance from Ref. Pt. (18), 1351m. Elevation, 99m.7021.

REF. PT. (20).—Top of spike driven into top of hickory stump 0m.3 diameter, 2m west of wagon track of Columbus road, and about 60m north from S. E. corner of last corn-fieldbefore getting to creek. It is 1409m from Ref. Pt. (19). Elevation, 100m.3255. Check Point is top of spike in top of hollow hickory stump 0m.2 diameter; stump 1m east of wagon track, and about 7m east of Ref. Pt., (20). It is 0m.0652 below Ref. Pt. (20).

REF. PT. (21).—Top of spike driven into top of stump 0.m.2 diameter; stump is 12m east of Columbus road; a tree on edge of road blazed. It is 2513m from Ref. Pt. (20) Elevation, 100m.0280. Check Point is top of spike in root of tree 15m north of Ref. Pt. (21), and 15m east of road. The tree is blazed. It is 0m.0542 above Ref. Pt. (21).

REF. PT. (22). Highest point of spike in root of hickory tree, 18m east of Columbus road; tree blazed. It is 716m from Ref. Pt. (21). Elevation, 100m.0176. Check Point is highest point of spike in top of oak stump 6m south of Ref. Pt. (22). It is 0m.1634 below Ref. Pt. (22).

REF. PT. (23).—Highest point of spike in top of old stump in middle of road 0m.8 diameter. Elm tree 0.m.6 diameter 7m west of road blazed. It is 497m from Ref. Pt. (22). Elevation, 100m.2482. Check Point is highest point of spike in root of blazed tree mentioned above. It is 0m.7556 below Ref. Pt. (23).

REF. PT. (24).—Highest point of spike in top of stump 0m.2 diameter, 2m south of top of south bank of slough, about 75m S. E. of point where Columbus road crosses. Slough connects two lakes, between which road crosses it. Tree 1m east of stump blazed. It is 712m from Ref. Pt. (23). Elevation, 98m.8530.

REF. PT. (25).—Highest point of spike in top of stump 0m.2 diameter, 3m west of Columbus road, and on north edge of small hollow. It is 554m from Ref. Pt. (24). Hickory tree 9m north of stump, and 1m east of road blazed. Elevation, 98m.2382.

REF. PT. (26).—Highest point of spike is in top of mulberry stump 0m.3 diameter, 3m south of Columbus road, and 15m east of point where it rises from bottom land to table land, about half mile before coming to bluff. Gum tree 12m N. W. of Ref. Pt., blazed and marked B. M. It is 936m from Ref. Pt. (25). Elevation, 101m.8307. Check Point highest point of spike in root of mulberry tree 0m.4 diameter, 3m west of Ref. Pt. (26). It is 0m.0371 below Ref. Pt. (26).

REF. PT. (27).—Highest point of spike in top of hickory stump 0m.4 diameter. Stump is on top of hill about 50m west of Columbus road at a point about midway up, cut from bottom land. It is 1464m from Ref. Pt. (26). Elevation, 129m.6268.

REF. PT. (28).—Highest point of spike in root of elm tree 12m east of road and 17m from top of bluff. Hickory tree with top broken off on west edge of road 23m north of Ref. Pt. blazed. It is 1,196m from Ref. Pt. (27). Elevation, 146m.4357. Check Point in root of maple tree 7m north of reference point. It is 0m.08 05 below Ref. Pt. (28).

REF. PT. (29).—Highest point of spike in root of hickory stump (?) 1m diameter, in middle of road, about 15m east of top of bluff at point, about 10m south of where saw logs are rolled down the hill. It is 781m from Ref. Pt. (28). Elevation, 145m.3220.

REF. PT. (30).—Highest point of spike in root of stump 0m.1 diameter, 13m east of junction of Columbus and Blandville road, and road coming in from east at the last point of woods before coming to Columbus. It is 931m from Ref. Pt. (29.) Elevation,

142m.7271. Check Point highest point of spike in root of tree 0m.2 in diameter, 45m south of Ref. Pt. (30). It is 0m.0541 below Ref. Pt. (30).

REF. PT. (31).—Highest point of spike in top of thorn tree stump 0m.2 diameter, 10m east of road, and about 90m N. E. of N. E. corner of old fort. It is 626m from Ref. Pt. (30). Elevation, 147m.5307.

REF. PT. (32).—Point on top of spike marked thus: (×) in top of wooden post 0m.8 long. Post set 0cm.2 below surface of ground, 0m.3 east of southeast corner of paling fence around large white house on top of bluff overlooking Columbus, on north side of main road going up the bluff. It is 966m from Ref. Pt. (31). Elevation, 136m.3251.

U. S. B. M. (7).—Middle of small hole in copper bolt set in south side of brick building, half way between the most eastern windows of main building in first course of bricks below window-sills; the building is situated on Front street, at Columbus, Ky., fronting on river, and belongs to the bank of Kentucky; it is called the "Mansion House," marked $\odot^{\text{U. S.}}_{\text{B. M.}}$ February 3, 1877. It is 971m from Ref. Pt. (32). Elevation, 102m.1226.

U. S. B. M. (8).—Center of small hole in top of copper bolt in stone post which is set in southeast corner of Baptist Church yard 1m.5 from each fence, The stone is marked by the letters U. S. It is 46m from U. S. B. M. (7). Elevation, 99m.9141,

U. S. B. M. (9).—Small hole in copper bolt set in east face of corner stone on northeast corner of same Baptist Church in Columbus, Ky. Church corner of Roam (?) street and Fourth street from river. Elevation, 100m.4521.

APPENDIX D.

REPORT OF ASSISTANT ENGINEER ARTHUR HIDER UPON OBSERVATIONS AT LAKE PROVIDENCE, NOVEMBER, 1879, TO NOVEMBER, 1880.

LAKE PROVIDENCE, LA., *October*, 1881.

SIR: The following report of the work done by the observation party under my charge stationed at Lake Providence, La., from October 31, 1879, to October 5, 1880, is respectfully submitted:

DESCRIPTION OF THE WORK.

The operations of the party were confined to cross-section soundings, to compare changes in form of transverse sections of the river; longitudinal soundings, at shoal and deep water places for the purpose of determining the forms, dimensions, and rate of motion of sand waves at highest, lowest, and intermediate stages of the river; sediment observations; dredgings of the bottom; and determination of the slope at different stages of water.

The party for this work was organized under your direction at Saint Louis, Mo., October 20, 1879, and consisted of two recorders, three rodmen, and the requisite number of boatmen, axemen, and a cook—in all eighteen men.

The party arrived at Lake Providence October 31, and work was at once begun by making a preliminary survey of the river to determine the best location for the observations which were to be undertaken.

That part of the river from about one mile above the town to a point about eight and one-half miles below was selected, as combining the requisites of shallow water with a wide river at the upper end of the reach, and deep water and a narrow section at the lower end. Between these points the river makes a regular bend to the left, the width varying greatly at different stages of water. At high water the width at the apex of the bend is 8,500 feet, while at low water it does not exceed 1,200 feet.

The special sections at the upper and lower end of the reach consisted of seven lines situated 500 feet apart, the ranges located so as to be as nearly as practicable at right angles to main current of the river. These sections are shown on Plate No. 1, which represents the river at low-water stage, and shows the location of all the cross-sections upon which soundings were taken. The shallow sections are numbered from 1 to 9, inclusive; the deep-water sections located at the lower end of the reach are numbered from 27 to 33, inclusive.

Both the shallow and deep sections were sounded twice each month, from November, 1879, to April, 1880, making twelve different soundings of each of these sections, including during this period low, intermediate stage, and high water.

From May, 1880, to October 15, 1880, the soundings of these sections were confined to Nos. 4, 5, 6, 7 of the shallow, and Nos. 30, 31, 32, 33 of the deep-water sections, which

were sounded from two to three times each week, and in addition, ten lines of longitudinal soundings, distributed about equally across the river, extending from the upper to the lower ranges at each of these localities, were made on the same day as the cross-section soundings.

Thirty-nine soundings of the cross-sections and 390 lines of longitudinals were obtained at each locality during this time.

Between the two sets of special sections above described at either end of the reach, the intermediate distance, about seven miles, was covered by cross-sections, located around the bend at distances of about 1,500 feet apart in mid-stream, and numbered on Plate I from 8 to 26, inclusive.

Soundings of each of these sections were made once a month from November, 1879, to May, 1880; seven different sets being obtained, covering low, intermediate stage, and high water.

The further sounding of these sections was discontinued, in accordance with your instructions of May 6, 1880, and the work of the party concentrated on the special sections above described. This was continued until the termination of the observations, October 15, 1880.

For the purpose of detecting sand waves, four lines of longitudinal soundings were made from one end of the reach to the other, about eight and one-half miles, every tenth sounding being instrumentally located.

During the progress of the work such portion of the force as could be spared from field work was employed in reducing and arranging the observations and plotting the field notes.

On the 22d of September, at which time I was assigned to other duties, all the soundings taken from the beginning of the work to September 1 had been reduced and plotted, and tracings made and forwarded to you.

The party was placed in charge of E. D. Thompson, who had served in the capacity of rodman, and under his directions the observations were continued until the close of the work, October 15, 1880. This was accomplished by him in a very satisfactory manner, with a small force, the two recorders having been transferred to other work at the time of his assuming charge.

The sediment observations were taken at the time of sounding the special shallow sections, on range 3, at intervals of about two weeks.

Dredgings were made at localities distributed over the entire reach, and at different stages of water.

Levels were continued along each bank the entire length of the reach, and bench-marks established near the different cross-section ranges for the convenience of obtaining slope observations.

These levels were continued from both shores over the sand-bars on each cross-section line at low water, to determine their elevation.

The slope of the river was obtained at the highest at nearly low water, and at intermediate stages for the whole length of the reach.

The shore line was located on both sides of the river the entire length of the reach, for the purpose of observing the change from time to time by caving of the banks.

The following is a list of the officers engaged on the work:

F. A. Yeager, recorder; Homer P. Ritter, recorder; T. C. Bradley, rodman; A. J. Frith, rodman; E. D. Thompson, rodman; E. D. Green, rodman; N. D. Gillespie, rodman.

To these gentlemen I am indebted in their different capacities for faithful attention to their several duties, and the success of the party was due to their exertions and the care with which each performed the special work allotted to him.

DESCRIPTION OF METHODS EMPLOYED.

Cross-section sounding.—All soundings taken were "drifting soundings." The boat was run up above the cross-section line being sounded, the lead cast and held about one foot from the bottom. As the boat drifted past the range line, the lead was allowed to touch the bottom, the depth noted and recorded.

In shallow water the soundings were taken from a skiff, the steam launch being employed in the deep water and rapid currents.

Each cross-section was marked by two range signals. These were made either of 1-inch boards about 3 feet square, painted white, or of white cotton, fastened to a frame of about the same size. These were attached to a post about 12 feet in length, securely planted in the ground, or to a small tree, the front signal being placed near the river bank, and the rear signal from 500 to 1,500 feet in shore.

The arrangement clearly defined the range line at any point in the river, and enabled the leadsmen to determine when the boat was exactly on range, so that soundings could be obtained on line, and rendered unnecessary the use of more than one instrument for locating the soundings.

The location of all soundings taken was determined instrumentally as follows:

Those taken from the steam launch were located by an observer on board with a sextant, by one angle to two of the stations on shore. When soundings were taken from a skiff, an observer with a transit occupied one of the stations on shore, at a sufficient distance above or below the range that was being sounded to give good intersections. The skiff was rowed a sufficient distance above the line being sounded to allow the lead being cast and held near the bottom and the boat to drift along with the current, so that as the range was crossed the lead line was as nearly vertical as possible; at the moment of crossing the range the recorder called "Sound!" and raised to a vertical position a small flag which he held in his hand as a signal to the observer on shore. The position of the lead line at the time of sounding was located by an angle taken from shore. The depth of water and the nature of the bottom was entered by the recorder, and the boat rowed to a new position. The cross-section soundings thus obtained were generally from 50 to 100 feet apart.

The lead used was about 22 pounds in weight, slightly hollowed out at the bottom, the space being filled with tallow so as to obtain specimens of the bottom at every cast of the lead. The line was an ordinary $\frac{3}{8}$-inch cotton line well stretched and marked with leather tags at every foot; it was frequently tested, and on the whole kept its length very well and gave but little trouble on that account. These tests were made from day to day, and when the length of the line had changed a sufficient amount to affect the accuracy of the work the line was retagged. A swivel was attached to the line near the lead which prevented the line from twisting when in use.

Longitudinal soundings.—These in all cases were taken from a skiff. The range across the river was divided up into about equal distances so as to allow ten lines to be taken in the width of the river. The boat was located in position by the aid of range signals on shore as shown on Plate II. An auxiliary range was placed about 100 feet above the upper range, so that the boat could be rowed to the intersection of the two ranges, the lead-line run out, and everything be in readiness to begin sounding as the boat drifted past the upper range. By this time the boat had lost its momentum, due to rowing, and was drifting along naturally with the current.

In conducting these observations a longitudinal line 500 feet in length, appropriately marked at every 5 feet by small cork floats, was first experimented with. A buoy was anchored in the river, to which the upper end of this line was fastened and the line allowed to float on the surface of the water in order to mark accurately the points where soundings were to be taken.

This did not give satisfactory results, as the least wind caused the skiff to cross the line and the lead became entangled, or the skiff drifted away from the line, and for the purpose of locating the soundings taken the line was useless. After a few attempts this plan was abandoned, and the method of marking the beginning of the line with buoys anchored in the stream was tried, but on account of the difficulty of keeping them in position in deep water and rapid currents, their constant destruction by drift and passing boats, this was also found impracticable, and the method first described of marking the beginning point of the longitudinal lines by intersections of ranges on shore adopted with more satisfactory results.

The appliance used in taking the longitudinal soundings to insure rapidity and accuracy is shown on Plate III. It consists of a wheel $2\frac{1}{2}$ feet in diameter placed near the stern of the skiff for taking up and letting down the line used in sounding, which, for this work, consisted of a continuous steel ribbon $\frac{3}{8}$ inch wide and about $\frac{1}{32}$ inch in thickness; this had small holes punched at the foot-marks, through which a small piece of brass wire was passed. In sounding, the intermediate depths between the foot-marks were estimated by the leadsman, which, with a little practice, could be done quite accurately; the 10-foot marks were distinguished by small tags of colored cloth.

This appliance gave very satisfactory results, and enabled the soundings to be much more rapidly and accurately taken than with an ordinary sounding line.

The soundings were taken as fast as they could be recorded; an average number of soundings on the ten lines taken was about 3,000, the distance apart of soundings from 3 to 8 feet.

It was found from an examination of the work, after reduction, that the cross-section soundings taken with an ordinary sounding line agree closely where the depth of water does not exceed about 40 feet; beyond this depth and in a swift current the difference is quite marked; at 60 and 80 feet of water the difference is from 3 to 4 feet, the soundings taken in deep and swift water with an ordinary lead line being greater than those taken with the above described appliance by from 3 to 5 per cent. where the water is over 60 feet in depth and the current swift; probably due to the action of the current on the larger line, which causes it to assume a greater curve.

A heavy lead, about 18 pounds in weight, was used. The moment the lead touched the bottom it could be distinctly felt by the jar communicated through the continuous steel ribbon. A swivel was also attached to this line about a foot from the lead;

this allowed the lead to whirl and twist in cross currents without twisting and breaking the line. The line seldom broke, and the appliance gave excellent results.

In determining the position of soundings two transits were used; one observer was placed at a station on the upper range, and the other observer on the lower range. The boat was rowed to the proper position in the river on the auxiliary range as indicated by the range signals on shore before described, and allowed to drift with the current until the upper range was crossed, the leadsman in the mean time allowing the line to run out over the wheel so that the lead would hang about a foot from the bottom.

At the instant the boat passed the upper range one of the boatmen close to the sounding line quickly raised a small flag which he held in his hand, an angle was taken on the sounding line by the observer at the lower station, as the flag assumed a vertical position and the sounding of the line began.

As the ninth sounding was taken and called by the leadsman, the recorder called "Flag!" and the flag was raised to a vertical position as the tenth sounding was taken; the position of the sounding line at this instant was located by an angle from both transits on shore. This continued until the boat passed the lower range; every tenth sounding being located by both instruments. When crossing the ranges the flagman called "Range!" and the recorder made a note opposite the proper sounding; this was done as a check on the work.

After a little practice the results obtained were very satisfactory; the limit of rapidity consisted in the ability of the recorder to enter the soundings; as many as 60 soundings a minute could be taken, and the six angles taken and recorded at each instrument to locate every tenth sounding.

The number of soundings obtained on a line 1,500 feet in length was from 175 to 500, depending upon the velocity of the current.

The soundings located instrumentally were afterwards plotted, the intermediate ones being equally distributed in the space between these, which agrees closely with the actual work, as in reality they were all cadenced soundings.

Sediment observations.—These were taken from a skiff drifting with the current; samples of water being obtained at surface, mid-depth, and one foot from the bottom. Two samples of two ounces each were taken at each place, and at eight different points distributed across the width of the river. These were afterwards arranged in horizontal and vertical combinations, properly labeled and packed, and forwarded to the office for analysis.

The appliance furnished by the office was used. The samples were taken on Range No. 3.

Dredgings.—These were distributed over the reach and at different stages of water. In this work an ordinary canvas dredge was used, a sketch of which is shown on Plate III. It was allowed to sink to the bottom and then dragged along the bottom up-stream until a specimen of the bottom was obtained; it was then pulled up, a sample taken, and the point where obtained located instrumentally from the launch by a sextant. The dredgings were generally made on the range lines.

Slope observations.—The method of conducting these observations was as follows:

At high water stakes were driven in the ground at each range line on the right bank, while the river was stationary; all of these stakes were driven within an hour; they were afterwards referred to bench marks before established at the different ranges. The highest water slope was also obtained at the same time from water-marks left by the flood on the trees. These marks were connected with the bench marks soon after the river fell.

The other observations were taken when the river was stationary, or nearly so; each set of observations was completed on the same day, and accurate gauge-readings made every hour while this work was in progress, to correct for any change in stage during the time the observations were being made.

Sand waves.—From a careful examination and comparison of the results of the observations taken at the shallow sections at the upper end of the reach in front of the town of Lake Providence, at the deep-water sections at the lower end of the reach, and also from soundings between these points, the form, size, rate of progress, and the approximate amount of material thus indicated as moving in waves along the bottom of the river have been determined.

These results have been deduced from careful measurements made from profiles of the river bottom at these points, drawn to a sufficiently large scale to insure accurate results. The profiles that have been compared, with notes of the comparisons made, are submitted in the form of an appendix to this report.

Thirty-nine different sets of observations were taken at the shallow sections and the same number at the deep-water sections; each of these sets of observations was completed on the same day, sets of soundings being taken alternately at the shallow and deep sections, from one to three observations being thus obtained at each locality every week.

The interval of time elapsing between the sets of soundings taken at each place

was from two to seven days. These observations were continued from May 11 to October 15, 1880, a period of about five months.

During this time the river assumed all the various stages from that of high to nearly low water; the stage, May 11, at the beginning of the observations, being 3½ feet below the highest water reached during the year, and at their termination, October 15, being within 3½ feet of low water.

Each of these sets of observations consisted of four lines of cross-section soundings 500 feet apart, extending across the river. The space between the upper and lower range, a distance of 1,500 feet, was covered by ten lines of longitudinals, distributed about equally in the width of the river.

The longitudinal soundings on each line were taken as nearly as practicable in the same place from day to day. It was found impossible to have the soundings of one day over those taken at a previous observation, on account of the difficulty of getting the boat in exactly the same position in the rapid current before beginning the sounding of a line, the change in the direction of the current at different stages of water, and the effect of wind on the boat, which caused its path to vary from time to time.

Any attempt to direct the course of the boat while a line was being sounded had to be abandoned, as the motion given the boat by using the oars resulted either in the current carrying the sounding lead ahead of the boat as it drifted down stream, or the boat traveling faster than the current, caused the lead to drag on the bottom, rendering the soundings taken inaccurate and worthless. In all cases the boat was got as nearly as possible in the proper position at the beginning of a line, and then allowed to drift with the current. No attempt was made to guide it in any particular direction.

The distances between the lines taken at the different observations are shown on the plots. The actual path of the skiff as the soundings were taken is plotted. The small circles are points in this line determined by intersecting angles from the two instruments on shore, one located on the upper range and the other on the lower; the space between these circles in every case is covered by ten soundings.

For convenience of comparison of the different lines as to position, a line at right angles to the range line is drawn at a certain distance from the right bank, to which the different lines of longitudinals can be referred as to location and direction.

The position of each sounding having been determined as heretofore described, it has been plotted on a sheet to a scale of 100 feet horizontal to 1 inch, and a vertical scale of 10 feet; cross and longitudinal sections are constructed on the different lines, thus giving a series of profiles of the river bottom, both transverse and longitudinal, from which comparisons have been made.

Twenty-seven sets of observations at the shallow sections and 26 sets of observations at deep sections have been compared; 108 different lines at the shallow, and 104 lines at the deep sections, about two-thirds of the observations taken, the remaining field notes not having as yet been plotted.

In addition to the above, a large number of lines of longitudinal soundings distributed over different parts of the reach and taken at frequent intervals have also been plotted and compared.

Tracings of such of these as have been used in makings comparisons are contained in the appendix.

FORMATION AND MOVEMENT OF SAND WAVES.

The amount of sedimentary matter carried in suspension varies at different localities and at different stages of water. As the velocity increases an additional amount is taken from the bottom and sides of the river by the action of the increased vertical currents, eddies, and boils brought into existence by this accelerated velocity, causing an erosion of the banks and a scour at the bottom.

At a rapid change from a lower to a higher stage this erosion of the bottom can readily be traced from one observation to another; if the rise is rapid and long continued, the waves existing before the change of stage commenced are entirely obliterated by erosion and a new series is developed as the river becomes stationary after this rise and a change to a lower stage begins. An instance of this action taken from the profiles in the appendix is shown on Plate IV.

A gradual fall of 13.8 feet occurred between May 11 and June 29, when the river rose rapidly 8.1 feet to July 19 and slowly began receding. Four days later, July 23, the fall was 1.7 feet and then became more rapid, until August 27 it had reached 20.8 feet. From June 29 to July 19, while the river was rising, the action of the increased velocity of the current on the bottom is plainly shown by a scour of an average of 4.3 feet and the gradual disappearance by erosion of the large wave that before existed.

As the river began falling after July 19, the development of a new series of low-water waves can be observed. As the river gradually approached a lower stage, these became more regular in their outlines and more clearly defined. A gradual filling of the bottom of 13.2 feet occurred during this period.

When the river remains at nearly the same stage for any length of time these waves appear on the bottom regular in form and are approximately uniform in their rate of progression, and it would seem that as the series of waves formed from time to time by the action of the current at about the same stage reappear so nearly of the same size, shape, and distance from crest to crest, their formation is in a measure due to some pulsation of the current, which, when the flow is uniform or nearly so, has its greatest effect on the bottom.

If the fall in stage is rapid and long continued, the waves which appeared at the higher stage become covered up and a new series of waves of smaller dimensions corresponding to the lower stage and the decreased velocity of the current are formed. An example of this is shown on Plate V, which shows high-water wave May 20, and low-water waves August 17, also changes in the bottom July 23–31 during a rapid fall in stage. This line is about 400 feet from the right bank ; on the line 800 feet from the right bank in the same locality is shown the bottom when the river was stationary, June 19, the changes occurring in the bottom from August 7 to August 27, the river falling 6 feet, and the development of low-water waves. A gradual filling of the bottom occurred on both these lines.

When the velocity is decreased, as shown by a falling river, the current being unable to support so large an amount of sedimentary matter as that with which it was charged at the higher velocity, by reason of decreased vertical currents, drops the surplus and a corresponding rising of the river bottom takes place ; an instance of this is shown on Plate VI, which represents the changes in the bottom on three longitudinal lines at the shallow sections, between ranges 4 and 7, a distance of 1,500 feet. These lines were located respectively 400, 800, and 1,200 feet from the right bank. During this interval the river fell 10 feet ; this was accompanied by a gradual filling of the bottom of an average of 3.5 feet over these lines.

By an examination of the profiles in the appendix from which these examples were taken, it will be found that at any stage, the most rapid rate of travel of the wave occurs when the river has been stationary, or nearly so, for a short time ; the waves then possess more regular outline, are nearly of the same dimensions, corresponding in size to the particular stage of water, and in location with reference to their distance from the thread of the main current, being greatest at high-water and decreasing in height and size as a lower stage is reached.

The largest waves are found in the deepest water and most rapid current, their size decreasing as the water becomes of less depth, until, in shallow water and removed from the main current, they resolve themselves into waves or ridges transverse to the direction of the current, varying from 20 to 100 feet apart and from a few inches to one or two feet in height.

These small waves can be observed extending over the sand bars immediately after a rapid decline in the stage of water leaves the bar exposed. They, however, soon become obliterated by winds moving the light sand of which they are composed and destroying their outlines.

It does not appear that waves of large enough dimensions to be accurately measured by sounding extend beyond the line of the main current and deep water. At the shallow sections the waves can be traced 1,500 feet from the right bank, and at the deep sections 1,800 feet; at other parts of the reach no waves of any great size were found except in deep water and a rapid current.

COMPARISON OF RESULTS.

Shallow-water sections.—Four lines have been selected for comparison : line No. 1, located about 400 feet from the right bank ; No. 2, 800 feet ; No. 3, 1,200 feet, and No. 4, 2,000 feet ; profiles of the bottom at these points have been grouped together and plotted, one over the other. Such lines only have been compared as are practically in the same position. (For location of lines, see Plate II.)

The first three sections include the deepest part of the river at this locality, and on these lines are indicated the greatest and most rapid changes in the bottom. The fourth line was selected as being on the crest of a bar which at extreme low water appears above the surface. In the shallow water beyond this the soundings do not indicate that the waves are of sufficient size or regularity to admit of their being traced or measured with any degree of accuracy.

The results of the measurements and comparisons of the height, length, and rate of progression of the waves have been arranged in tabular form and are contained in the appendix, to which reference is made, and from which the following results have been taken :

HIGH-WATER STAGE.

Distance from right bank.	Average length of wave.	Average height of wave.	Maximum height.	Maximum rate of travel.	Average rate of travel.	Depth of water.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
400	750	18.3	22	40	33.2	90
800	400	12.0	15	45	19.3	80
1,200	250	8.0	.....	25	15.0	55

On line 2,000 feet from the right bank the bottom consisted of a series of small waves or ridges, averaging about 45 feet apart, and from 1 to 3 feet in height. This line is in comparatively shoal water, the depth at high-water being about 33 feet; but slight changes at different stages occurred on this line.

STAGE 25 FEET BELOW HIGH WATER.

Distance from right bank.	Average length of wave.	Average height of wave.	Maximum height.	Maximum rate of travel.	Average rate of travel.	Depth of water.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
400	240	8.0	8.0	8.8	8.2	60
800	265	6.7	8.0	15.0	11.2	50
1,200	250	6.0	6.0	.....	.....	28

Deep-water sections.—In comparing results of observations taken at this point three lines have been selected: No. 1, 600 feet from the right bank; No. 2, 1,000 feet; No. 3, 1,400 feet. These lines are distributed over the low-water channel. (See Plate II.)

These have been compared in a similar manner to those at the shallow-water sections. The profiles, results of the measurements, &c., are contained in the appendix, from which the following is obtained:

HIGH-WATER STAGE.

Distance from right bank.	Average length of wave	Average height of wave.	Maximum height.	Maximum rate of travel.	Average rate of travel.	Depth of water.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
600	310	5	8	.....	.....	80 to 95
1,000	286	6.6	7.5	81	46	85 to 100
1,400	400	9	11.5	37	37	80 to 85

STAGE 20 TO 25 FEET BELOW HIGH WATER.

Distance from right bank.	Average length of wave.	Average height of wave.	Maximum height.	Maximum rate of travel.	Average rate of travel.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
600	273	5.3	7	.....	.....
1,000	307	6.5	7	14.2	14.2
1,400	395	10.1	.....	7.4	7.4

The section of the river at this point is narrow and deep, with a steep declivity from both banks. The waves are more difficult to trace than at the shallow sections. The bottom appears to be undergoing rapid and continued change, due, probably, to the concentration of so large a volume of water discharging through a narrow section.

MOVEMENT OF MATERIAL ALONG THE BOTTOM.

Velocities sufficient to move gravel and small bowlders are known to exist within a few feet of the bottom, and although the dredgings and sediment observations taken do not seem to indicate the presence of any large quantities of moving material, it seems reasonable to suppose that a considerable amount of material at high stages of water is swept along close to the bottom by the action of the current.

In order to determine, if possible, whether any such rapid and continuous changes

were in progress on the bottom as would necessarily occur were large amounts of material in motion, soundings for a number of days were confined to a single line. The soundings were at first taken once a day, afterwards twice, and for several days they were taken every hour. Plate VII shows the movement of material along the bottom at high-water stage, and the method of progression of the wave and its obliteration by deposit as the river falls. Range of observations, five days. These observations were taken 800 feet from the right bank, between ranges 3 and 6, the profiles compared being practically one over the other; the length of each line is 1,500 feet, and about 300 soundings are represented on each line.

The changes occurring between the two observations taken February 9 at 10 a. m.–5 p. m. are indicated by a heavy and light line respectively; February 10, 5 p. m., by a heavy dotted line; February 13 by a heavy black line, and February 14, 9 a. m.–5 p. m., by a light full line and heavy dotted line. The profile first taken February 9, at 10 a. m., is repeated with the last profiles, to indicate more clearly the changes that have taken place during the time that the observations were taken.

From an examination of the profiles it is seen that rapid and continuous changes are constantly going on, the material being swept along near the bottom, filling up irregularities and piling isself up in new ridges. These in turn are again carried away by the attrition of the material being swept along and the abrading action of the current.

By comparing the profile taken February 9, 10 a. m., with that taken February 14, 5 p. m., the method of wave progression can be clearly seen. It will also be observed that the small waves or ridges appear to retain their form and individuality for but a short time, the material sweeping along the bottom causing rapid changes in their form. This movement of material can be plainly traced from one observation to another.

The method of progression of the waves in high stages of water, and when the current velocity is greatest, is by an erosion of their upper slopes and an accretion to their length by deposit over their crests of the heavier portion of the eroded material taken from their upper slopes, the lighter material being taken up by the vertical currents and carried forward in a state of suspension. In this manner the heavier material, coarse sand, gravel, and small bowlders, evidently make their way down stream by being rolled or pushed up the flat slope of the wave and dropped over the crest, there to remain until the wave has progressed far enough down stream to leave this material again exposed to the action of the current, when it is again rolled or pushed forward.

Plate VIII represents changes in the bottom at high-water stage, the river being stationary.

These observations were taken on the same line from day to day. The line is about 800 feet from the right bank, between ranges 13 and 14. The soundings were taken at short intervals of from one to three hours, and extended over a period of four days. On these profiles are shown the rapid and constant changes taking place, indicating that a large amount of material is swept along the bottom at high water.

By comparing the profile taken May 4, 8.30 a. m., shown by a dotted line, with those taken May 7, marked *, the beginning of the gradual development of a high water wave can be detected.

From a careful examination of the above profiles contained in Plates IV to VIII, and from numerous others contained in the appendix, to which reference is made, it would appear that but a comparatively small portion of the amount of the material actually moving along the bottom at high stages of water is indicated on the profiles by the progress of the waves, a much larger portion being swept along close to the bottom and not detected in sounding.

An estimate of the amount of material moving along the bottom at high-water stage as measured by the wave accretion, taking the average height and rate of travel as deduced from the plotted profiles contained in the appendix, is as follows:

SHALLOW SECTIONS.

Feet from right bank.	Average height.	Average travel per day.
	Feet.	*Feet.*
400	18.3	33.2
800	12.0	19.3
1,200	8.0	15.0
2,000	3.0	10.0
Mean	10.3	19.4

Width of river at high water, 4,500 feet. Amount represented by wave accretion is $2,000 \times 10.3 \times 19.4 = 399,640$ cubic feet, or 14,800 cubic yards. Assuming even that the above amount represents as much as ten per cent. of the *actual* amount moving along on the bottom (and it is believed that this estimate is excessive), 148,000 cubic yards of material are thus transported every twenty-four hours.

As no method has been devised to measure accurately material thus in motion on the bottom, the above can only be taken as giving a crude idea of the large amount of material that is carried forward in this manner.

CONCLUSIONS.

A summary of the conclusions deduced from an examination and comparison of the observations that have been reduced is given below:

1. That the bottom of the river is in an unstable condition and constantly in a state of motion; the amount of material thus moving along the bottom in waves depends on the velocity of the current and the depth of water, being the greatest when from any cause the velocity of the current is suddenly increased, at which time the most rapid erosion of the bottom takes place, and conversely the movement of material along the bottom is least when the velocity of the current is suddenly decreased, as then the greatest deposit of sedimentary matter occurs.

2. That the bottom of the river consists of a series of ridges irregular in shape, transverse to the direction of the current, which in deep water and the most rapid current, under favorable conditions become more regular in shape and size, approaching the form of waves. That these waves have an irregular motion down stream, and that the maximum size and rate of progression is attained when the river is at its highest stage and nearly stationary, their height, length, and rate of motion being dependent on their location with reference to their distance from the thread of the main current. The waves have the least dimensions and slowest rate of travel at low-water.

3. That the heavier material makes its way down stream by being pushed or rolled up the flat anterior slope of the wave by the action of the current and is dropped over the crest of the wave, where it remains until the wave has progressed far enough down stream to leave it again exposed to the action of the current, to be again rolled or pushed forward. The amount of heavier material thus moving is greatest in high water, or when the velocity of the current from any cause has been suddenly accelerated.

4. That changes in the form of the waves are gradual, the waves retaining their form and individuality so long as the velocity of the current remains nearly uniform; that they are destroyed by a rapid increase of velocity by erosion, and are obliterated by deposition of sediment, when the velocity is suddenly decreased. They again make their appearance when the velocity of the current approaches uniformity for any length of time.

5. That a large amount of material is transported near the bottom. The amount as measured by the progression of the waves, as shown on the profiles, it is believed represents but a small amount of the material actually in motion along the bottom.

The practical results of the above conclusions derived from the preceding investigations seem to indicate—

1. The possibility of bottom accretions and deposits being obtained by the use of permeable works located near the bottom.

2. The necessity of the fixed supports used in works of improvement being sunk to a sufficient depth to be beyond the limit of scour as indicated by the wave or reef action.

TRAVEL OF SAND BARS.

The bars formed in the river channel move down stream by deposit of sediment at their lower extremities, and a gradual cutting away of their upper ends by the abrading action of the current.

An example of the method of bar growth is shown on Plate IX. The observations were taken at flood stage. This bar is located between ranges 14 and 19, and at low water extends out from the right bank.

From measurements made from the plotted cross-sections, the following rate of travel of the different bars has been determined:

Shore bar, left bank, between ranges 1 and 4. Movement in six months, November, 1879, to May, 1880, from low to high water, 1,765 feet.

Middle bar, between ranges 7 and 14.—During the same period the upper end of this bar receded by cutting 1,100 feet, and the bar moved down stream by accretions at its lower extremity 980 feet.

Shore bar, right bank, between ranges 14 and 19. This bar increased its length at its lower end during the same time 1,050 feet.

CROSS-SECTION SOUNDINGS.

In order to determine the changes that take place in the form and area of the transverse section of the river, at different stages, the following cross-sections have been selected for comparison, viz: Sections No. 1, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 29, and 33. For location of sections see Plate I.

Sections 1, 5, 29, and 33 were sounded at intervals of about two weeks, from November, 1879, to May, 1880, and sections 8 to 26, inclusive, monthly during the same period, making twelve different soundings of each of the first four sections and seven of each of the remaining ones. This period covered low-water stage in November, 1879, and the flood stage in April, 1880. Twenty-three sections have been compared, covering a distance of about $8\frac{1}{2}$ miles.

A gauge was established on the right bank at Section 7, which was read three times each day. The water surface on each section was plotted to agree with the gauge reading at the time the soundings were taken. The work has been plotted to a scale of 500 feet horizontal to one inch, and a vertical scale of 50 feet, and the area of each section between an assumed datum line at the height of 200, measured by the aid of a planimeter.

Corrections of height of water surface at different stages, due to change of slope, have been determined by means of the slope diagram shown on Plate XI, as follows: A straight line is drawn to represent the gauge at Section 7, and the water surface, above or below, at each section for the particular stage when the soundings were taken has been measured from the diagram upon which is plotted the change in slope at each section at the different gauge heights at which the slope observations were taken. The corrections for intervening stages have been taken from the diagram, assuming that between these heights the change of slope has been regular. The correction, thus found, has been applied to the measured datum areas so that each area of cross section, given in the tables, is measured from the same datum line which represents 200 on the gauge.

The highest water reached was 202.53, and the lowest 166.6; a range of 36 feet.

This correction to the measured areas was necessary on account of the change in slope from high to low water; for instance, the fall between Section 1 and 33 at high water is 2.648 feet, while at a stage 27.2 feet below the fall is 4.128 feet. In the following tables are shown the gauge readings, widths, areas, scour and fill, and the mean depth of the different sections compared:

No. of section.	Date.	Gauge.	Width.	Area below datum.	Scour.	Fill.	Mean depth.
1	November 11	166.6	4772	204433	.....	.....	42.86
1	November 24	170.2	4751	206133	1700	.....	43.39
1	December 9	176.7	4777	204647	.....	1486	42.84
1	December 30	192.0	4762	204182	.....	465	42.86
1	January 19	199.3	4747	197153	.....	7029	41.53
1	January 30	200.3	4745	192513	....	4640	40.57
1	February 14	188.8	4795	193693	1180	.....	40.39
1	February 28	199.3	4790	190901	.....	2792	39.85
1	March 13	201.7	4785	186872	.....	4029	39.05
1	March 29	202.41	4782	183456	.....	3416	38.34
1	April 1	202.09	4780	169679	.....	13777	35.49
1	April 27	200.4	4787	190636	20957	.....	39.82
5	November 12	166.7	4450	188239	.....	.....	42.30
5	November 24	170.3	4457	197007	8768	.....	44.20
5	December 13	176.9	4442	198778	1771	.....	42.49
5	January 3	193.8	4440	201944	3166	.....	45.48
5	January 19	199.3	4442	200785	.....	1159	44.99
5	January 30	200.4	4445	198408	.....	2377	44.63
5	February 14	188.5	4467	220553	22145	.....	49.37
5	March 1	199.9	4460	197785	.....	22768	44.34
5	March 17	201.8	4470	197347	.....	438	44.17
5	March 30	202.4	4460	203974	6627	.....	45.73
5	April 12	202.1	4450	185144	.....	18830	41.60
5	April 27	200.4	4492	213914	28770	.....	47.62
8	November	166.52	5015	185250	.....	.....	37.00
8	December	179.6	5090	201269	16019	.....	39.54
8	January	197.3	5150	203838	2569	.....	39.58
8	February	199.55	5255	206328	2490	.....	39.24
8	March	200.10	5230	210627	4299	.....	40.27
8	March and April	202.41	5260	200736	.....	9891	38.16
8	May	199.3	5160	216227	15491	.....	41.90
9	November	166.47	4850	183347	.....	.....	37.80
9	December	179.6	4985	188874	5527	.....	37.90

No. of section.	Date.	Gauge.	Width.	Area below datum.	Scour.	Fill.	Mean depth.
9	January	197.3	4955	187844	.....	1030	38.11
9	February	199.5	4975	186922	.....	922	37.41
9	March	200.12	5010	194101	7179	.....	38.74
9	March and April	202.41	5125	191563	.....	2538	37.38
9	May	199.3	5005	212180	20617	.....	43.93
10	November	166.47	4680	177668	.....	.....	37.98
10	December	179.6	4715	193525	15857	.....	41.04
10	January	197.6	4715	187445	.....	6080	39.75
10	February	199.5	4715	179586	.....	7859	38.08
10	March	200.22	4755	175396	.....	4190	36.88
10	March and April	202.41	4760	182077	6681	.....	38.25
10	May	199 3	4740	192562	10485	.....	40.62
11	November	166.52	4445	169639	.....	.....	38.16
11	December	179.6	4450	186242	16603	.....	41.82
11	January	197.6	4475	193058	6816	.....	43.14
11	February	199.4	4470	184065	.....	8993	41.18
11	March	200.4	4465	179446	.....	4619	40.19
11	March and April	202.37	4465	182044	2598	.....	40.77
11	May	199.3	4450	191516	9472	.....	43.03
12	November	166.55	4375	175156	.....	.....	40.26
12	December	179.6	4353	179304	4148	.....	41.17
12	January	197.6	4395	186664	7360	.....	42.47
12	February	199.4	4415	188105	1441	.....	42.60
12	March	200.22	4400	178735	.....	9370	40.62
12	March and April	202.41	4390	174590	.....	4145	39.31
12	May	199.3	4395	187128	12538	.....	42.58
13	November	166.6	4585	188330	.....	.....	41.07
13	December	179.6	4545	193988	5658	.....	42.68
13	January	198.55	4600	198759	4771	.....	43.21
13	February	199.0	4610	188188	.....	10571	40.82
13	March	200.25	4595	192892	4704	....	41.97
13	March and April	202.37	4610	176563	.....	16329	38.30
13	May	199.3	4595	196186	19623	.....	42.69
14	November	166.45	4850	211010	.....	.....	43.50
14	December	188.2	4855	216245	5235	.....	44.54
14	January	198.6	4840	214968	.....	1277	44.42
14	February	199.0	4855	197654	.....	17314	40.71
14	March	200.6	4860	199957	2303	.....	41.14
14	March and April	202.37	4890	190537	.....	9420	38.14
14	May	199.3	4880	201205	10668	.....	41.84
15	November	166.35	5725	226163	.....	.....	39.50
15	December	188.3	5715	236789	10626	.....	41.43
15	January	198.6	5630	225841	.....	10948	40.11
15	February	198.95	5635	218777	.....	7064	38.82
15	March	200.6	5635	221196	2419	.....	39.25
15	March and April	202.36	5575	196933	.....	24263	35.32
15	May	199.3	5655	211809	14876	.....	37.46
16	November	166.30	6550	232434	.....	.....	35.48
16	December	188.40	6530	239850	7416	.....	36.73
16	January	198.94	6530	233334	.....	6516	35.73
16	February	198.80	6540	229528	.....	3806	35.09
16	March	200.75	6535	221415	.....	8113	33.88
16	March and April	202.42	6565	202664	.....	18751	30.87
16	May	199.30	6525	216212	13548	.....	33.14
17	November	166.35	7490	241697	.....	.....	32.27
17	December	188.5	7465	251149	9452	.....	33.64
17	January	199.0	7400	254242	3093	.....	34.35
17	February	198.8	7400	243168	.....	11074	32.86
17	March	200.55	7395	249680	6512	.....	33.76
17	March and April	202.42	7425	211753	.....	37927	28.65
17	May	199.3	7410	239696	27943	.....	32.35
18	November	166.35	8130	266634	.....	.....	32.79
18	December	191.4	8245	278578	11944	.....	33.79
18	January	198.95	8235	278254	.....	324	33.79
18	February	198.75	8235	256629	.....	21625	31.16
18	March	200.78	8225	257367	738	.....	31.29
18	March and April	202.36	8230	239428	.....	17939	29.09
18	May	199.38	8235	243092	3664	.....	29.52
19	November	166.4	8550	272625	.....	.....	31.88
19	December	183.6	8535	342783	70158	.....	40.16
19	January	199.97	8480	348399	5616	.....	41.09

No. of section	Date.	Gauge.	Width.	Area below datum.	Scour.	Fill.	Mean depth.
19	February	197.90	8490	335503	.....	12896	39.52
19	March	200.78	8485	319026	.....	16477	37.60
19	March and April	202.40	8500	289595	.....	29431	34.07
19	May	199.4	8465	292122	2527	.....	34.57
20	November	166.40	8180	255096	.....	.....	31.18
20	December	183.60	7915	260980	5884	.....	32.98
20	January	199.55	8230	293257	32277	.....	35.63
20	February	197.95	7665	303150	9893	.....	39.55
20	March	200.95	8215	313790	10640	.....	38.19
20	March and April	202.40	8230	317233	3443	.....	38.54
20	May	199.40	8285	328279	11046	.....	39.63
21	November	166.40	7735	214541	.....	.....	27.73
21	December	191.50	7710	229780	15239	.....	29.80
21	January	199.75	7870	271717	41937	.....	34.53
21	February	198.00	7765	257310	.....	14407	33.14
21	March	200.95	7285	262970	5660	.....	36.12
21	March and April	202.36	7895	275404	12434	.....	34.92
21	May	199.40	8285	328279	11046	.....	39.63
22	November	166.40	7365	183841	.....	.....	24.95
22	December	191.20	7585	233849	50008	.....	30.83
22	January	198.95	7575	239806	5957	.....	31.65
22	February	198.10	7545	252089	12283	.....	33.41
22	March	200.95	7590	262849	10760	.....	34.63
22	March and April	202 40	7605	256376	.....	6473	33.73
22	May	199.48	7615	252116	.....	4260	33.11
23	November	166.40	6775	240444	.....	.....	35.49
23	December	191.30	7045	218806	.....	21638	31.06
23	January	199.75	7305	235530	16724	.....	32.24
23	February	196.10	7345	230047	.....	5483	31.32
23	March	201.45	7350	234731	4684	.....	31.93
23	March and April	202.15	7375	210229	.....	24502	28.50
23	May	199.48	7350	258919	48690	.....	35.22
24	November	166.40	6480	222830	.....	.....	34.38
24	December	191.30	5910	203397	.....	19433	34.42
24	January	199.75	6165	226034	22637	.....	36.66
24	February	196.10	6690	231475	5441	.....	34.60
24	March	201.68	6760	216279	.....	15196	31.99
24	March and April	202.25	6770	225835	9556	.....	33.38
24	May	199.48	6725	234312	8487	.....	34.84
25	November	166.40	5710	220598	.....	.....	38.63
25	December	191.30	5565	107774	.....	22824	35.54
25	January	199.60	5050	175648	.....	22126	34.78
25	February	196.10	5090	228823	53175	.....	44.95
25	March	201.45	5680	229451	628	.....	40.39
25	March and April	202.25	5985	230680	1229	.....	38.54
25	May	199.80	5965	238257	7577	.....	39.94
26	November	166.4	4795	176354	.....	.....	36.79
26	December	190.90	4795	156735	.....	19619	32.69
26	January	198.45	3845	165113	9378	.....	42.94
26	February	196.00	3600	182160	17023	.....	50.59
26	March	201.68	3570	179300	.....	2836	50.22
26	March and April	202.25	3970	215462	36162	.....	43.35
26	May	199.80	3980	218520	3058	.....	43.85
29	November	165.5	4077	185975	.....	.....	45.61
29	November	176.4	4077	189868	3893	.....	46.57
29	December	191.7	4177	183988	.....	5880	44.03
29	January	198.2	4160	190587	6599	.....	45.81
29	January	200.0	4215	167960	.....	22627	39.84
29	February	192.4	4060	179756	11796	.....	44.27
29	February	188.1	3837	173789	.....	5967	45.29
29	February	195.0	4175	177106	3317	.....	42.42
29	March	201.5	4232	186418	9312	.....	44.05
29	March	202.3	4232	185391	.....	1027	43.80
29	April	202.2	4230	177756	.....	7635	42.02
29	April	200.8	4232	197566	19810	.....	46.68
33	November	166.50	3657	184999	.....	.....	50.61
33	November	176.35	3657	176861	.....	8138	48.36
33	December	190.90	3657	184420	7559	.....	50.42
33	January	198.40	3862	194369	9949	.....	50.32
33	January	199.00	3875	192427	.....	1942	49.65
33	February	192.10	3825	194948	2521	.....	45.73
33	February	188.15	3800	170357	.....	24591	44.83
33	February	195.00	3822	173913	3556	.....	45.50
33	March	201.50	3870	172047	.....	1866	44.45
33	March	202.32	3872	173800	1753	.....	44.88
33	April	202.17	3865	172807	.....	993	44.71
33	April	200.80	3872	185973	13166	.....	48.03

For easier comparison of change in areas at different stages, the following table has been arranged, showing the low-water survey, November, 1879; survey at medium stage, December, 1879; high water, January; flood stage, April, 1880, and high water of May, 1880. The mean depths at each section have been plotted. (See Plate X.)

Number of section.	November, 1879, low water, mean gauge 167.3.	December, 1879, medium stage, mean gauge 185.3.	January, 1880, high water mean guage.	April, 1880, flood stage, mean gauge 202.3.	May, 1880, high water, mean gauge 199.7.
1	204433	204182	197153	169679	190636
5	188239	201944	200785	185144	213914
8	185250	201269	203838	216227	200736
9	183347	188874	187844	191563	212180
10	177668	193525	187445	182077	192562
11	169639	186242	193058	182044	191516
12	175156	179304	186664	174590	187128
13	188330	193988	198759	176563	196186
14	211010	216245	214968	190537	201205
15	226163	236789	225841	196933	211804
16	232434	239850	233334	202264	216212
17	241697	251149	254242	211753	239696
18	266634	278578	778254	239428	243092
19	272628	342783	348399	289595	292122
20	255096	260980	293257	317233	328279
21	214541	229780	271717	275404	296333
22	183841	233849	239806	256376	252116
23	240444	218806	235530	210229	258919
24	222830	203397	226034	225835	234312
25	220598	197794	175648	230680	238257
26	176354	156735	165113	215462	218520
29	185975	183988	190587	177756	197566
33	184999	184420	194369	172807	185973

From the above observations it will be seen that an increase of area at nearly every section takes place as the river passes from low to medium stage, caused by enlargement and deepening of the channel, due to erosion of the bottom by the increased velocity of the current.

The exceptions to this are sections 23 to 33, inclusive, where the reverse is the case. This is evidently from local causes. An examination of the December survey shows that at this stage a large amount of water is passing through the chute on the left bank, which has become considerably enlarged; this meeting the main current, passing along close to the right bank, causes a decrease of velocity at this point, and consequently, a deposit of part of the eroded material being carried forward in suspension; this filling gradually decreases in amount, until at section 33 it practically amounts to nothing.

The filling at section 1 is probably from a similar cause due to the chute around Stack Island, which enters the main river a short distance above.

The same increase of area and deepening of channel take place as the river continues rising to high-water stage in January.

A reference to the profiles, Plate X, will show that at flood stage in April, at which time the river overflowed its banks the entire length of the reach, a marked decrease of area occurred at nearly every section, and that as soon as the water subsided sufficiently for the flood water to be retained within the natural channels, as shown by the survey made in May, a scour of the bottom took place, and the material deposited in the river bed, when the water was spread out over the adjacent low grounds, was rapidly eroded.

The following table gives the mean gauge reading, widths, depths, and areas of each of the seven surveys made.

From this it can also be seen that the channel of the river gradually enlarges from low to high water. As the river overflows its banks (which occurs along the entire reach between 198 and 200 on the gauge), a filling of the bottom takes place, causing a decrease in the area of section. This filling, done at flood stage, is carried away as soon as the river is again confined, at which time the maximum rate of scour occurs.

Mean of twenty-three sections.

Date.	Mean of gauge readings.	Mean of widths.	Mean of depths.	Mean of areas.
1879.				
November 12–17	167 3	5, 765	36. 25	209, 030
December 13–29	185. 5	5, 764	37. 57	216, 587
January 9–21	198. 8	5, 767	38. 36	221, 243
February 3–7	197. 9	5, 755	38. 22	219, 981
March 1–11	200. 8	5, 799	37. 73	218, 797
March 13–April 10	202. 3	5, 912	36. 13	213, 626
May 1–11	199. 7	5, 900	38. 42	226, 729

NOTE.—Gauge, February 15, 192.0.

SLOPE.

Below are arranged in tabular form the changes in slope due to change of stage, from which the diagrams shown on Plate XI have been plotted for correction of cross-section areas:

Table showing the fall between ranges at different stages of water.

Gauge reading.	Elevation of water surface in feet referred to range 7.						Distance between ranges. †	Remarks.
	*202. 53	201. 71	195. 62	188. 13	179. 57	175. 27		
							Feet.	
Range 1	0. 192	0. 080	0. 050	0. 039	0. 015	—0. 082	0	
4	0. 100	.....	0. 149	0. 115	—0. 057	—0. 086	1, 500	
7	. 0	. 0	. 0	. 0	. 0	. 0	1, 500	Gauge.
8	—0. 146	—0. 313	—0. 103	—0. 124	—0. 050	—0. 205	1, 700	
9	—0. 165	—0. 449	—0. 203	—0. 197	—0. 092	—0. 277	1, 750	
10	—0. 282	—0. 656	—0. 353	—0. 444	—0. 453	—0. 738	1, 750	
11	—0. 418	—0. 620	—0. 545	—0. 631	—0. 678	—C. 976	1, 630	
12	—0. 416	.....	—0. 809	—0. 817	—0. 846	—1. 140	1, 650	
13	—0. 873	—0. 938	—0. 840	—0. 845	—0. 910	—1. 195	1, 700	
14	.....	—1. 038	—0. 931	—0. 841	—0. 940	—1. 91	1, 770	
15	—0. 876	—1. 145	—0. 914	—0. 976	—1. 010	—1. 363	1, 800	
16	—0. 961	—1. 277	—0. 988	—1. 167	—1. 769	—1. 952	1, 780	
17	—1. 028	—1. 362	—1. 249	—1. 595	—1. 935	—2. 238	1, 630	
18	—1. 079	—1. 369	—1. 344	—1. 723	—2. 329	—2. 540	2, 000	
19	—1. 199	—1. 300	—1. 452	—2. 024	—2. 673	—3. 140	2, 200	
20	—1. 075	—1. 390	—1. 420	—2. 024	—2. 635	—3. 080	2, 140	
21	—1. 128	—1. 492	—1. 513	—2. 008	—2. 615	—3. 150	2, 250	
22	—1. 227	.....	—1. 569	—2. 085	—2. 755	—3. 210	2, 450	
23	—1. 336	.....	—1. 589	—2. 176	—2. 792	—3. 429	2, 000	
24	—1. 478	.....	—1. 912	—2. 597	.....	.....	2, 380	
25	—1. 790	.....	—2. 344	—2. 997	—3. 535	—4. 120	2, 120	
26	—2. 082	.....	—2. 387	—3. 036	.....	.....	2, 000	
27	—2. 157	.....	—2. 690	—3. 064	—3. 801	—4. 139	1, 650	
30	—2. 420	.....	—2. 865	—3. 159	—3. 671	—4. 142	1, 500	
33	—2. 628	—2. 793	—2. 960	—3. 241	—3. 777	—4. 128	1, 500	

*High water. † Total distance between ranges, 44,350 feet, or 8.4 miles.

On Plate XI is also plotted the slope of the river as determined by the slope observations along the right bank from range 1 to 33, a distance of 8.4 miles. These observations were taken at extreme high water, and at 0.8 feet, 6.9 feet, 14.4 feet, 23 feet, and 27.2 feet below.

It will be observed that at high stages the slope is comparatively regular, the greatest slope being found between ranges 12–13 and 24–33; at medium stage the steepest slope is found between ranges 15–18 and 23–25, while at the lowest stage the regularity of the slope is again broken by a rapid fall between 7–12.

It will be seen that the slope varies greatly at different stages; in this locality increasing as the river falls, being the greatest at low water, the profile being made up of a number of planes with inclinations varying with the particular stage.

Summary.

CROSS-SECTION SURVEYS.

Monthly surveys of reach	7
Monthly surveys of shallow sections	12
Monthly surveys of deep sections	12
Surveys of shallow sections in connection with longitudinal soundings	39
Surveys of deep sections in connection with longitudinal soundings	35
Total number of located cross-section soundings	21,755
Number of miles of cross-section sounded	444.9

LONGITUDINAL SURVEYS.

Shallow sections	39
Deep sections	39
Surveys of entire reach	1
Special surveys at different points	27
Number of soundings taken	325,526
Number of soundings located	32,552
Number of miles sounded	330

SEDIMENT.

Nnmber of observations	24
Number of soundings	192
Number of samples taken	576

MISCELLANEOUS.

Number of slope observations	125
Number of dredgings	339
Number of miles levels run	31
Nnmber of signals erected and located	66

SEDIMENT.

Samples of the water for the purpose of determining the amount of sediment carried in suspension were taken from November, 1879, to October, 1880, at intervals of about two weeks.

The reduction of these observations was made at the office; the results are not at hand and so cannot be given.

DREDGINGS.

A sample of each of the specimens of the bottom, obtained by dredging, as before described, was carefully examined with the aid of a lens and a micrometer scale, and the percentage of different sized material in each specimen determined; the results have been arranged in tabular form and are given below.

The dimensions adopted for comparison are as follows:

Material between $\frac{1}{1000}$ and $\frac{1}{100}$ of an inch diameter.
Material between $\frac{1}{50}$ and $\frac{1}{25}$ of an inch diameter.
Material between $\frac{1}{25}$ and $\frac{1}{10}$ of an inch diameter.
Material larger than $\frac{1}{10}$ of an inch diameter.

Tabular statements.

LONGITUDINAL DREDGINGS.

BETWEEN RANGES 1 AND 11, MAIN CHANNEL, RIGHT OF MIDDLE BAR.

Date.	Stage of river.	Number of specimens taken.	Per cent. of material in specimens, diameter to one inch.				
			1000 to 100	100 to 50	50 to 25	25 to 10	Larger than .1 of one inch diameter.
1879.							
Dec. 5 & 6	176.0	12	29.7	42.5	15.5	.....	12.3 gravel from .5″ to 1″ diameter.*

* Ranges 12 and 13 the entire specimens were gravel one-eighth and three-quarter″ in diameter.

BETWEEN RANGES 1 AND 34, MAIN CHANNEL, LEFT OF MIDDLE BAR.

Date.	Stage of river.	Number of specimens taken.	Per cent. of material in specimens, diameter to one inch.				
			1,000 to 100	100 to 50	50 to 25	25 to 10	Larger than .1 of one inch diameter.
1879.							
Dec. 5 & 6	176.0	32	57.9	37.5	4.2	.....	0.4 gravel from $\frac{1}{8}''$ to $\frac{1}{4}''$ diameter. †

BETWEEN RANGES 8 AND 11, MAIN CHANNEL, BETWEEN RIGHT BANK AND MIDDLE BAR.

1880. Sept. 6	173.6	7	4.4	36.0	13.0	33.6	13.0 gravel from .1″ to 1″ in diameter.

BETWEEN RANGES 11½ TO 14½, MAIN CHANNEL, BETWEEN RIGHT BANK AND MIDDLE BAR.

Sept. 6	173.6	7	56.0	37.0	2.0	5.0	.....

BETWEEN RANGES 8 TO 11½, BETWEEN RIGHT BANK AND MIDDLE BAR.

Sept. 9	.....	8	88.0	12.0	.....	.....	.....

BETWEEN RANGES 12 TO 15, MAIN CHANNEL, BETWEEN RIGHT BANK AND MIDDLE BAR.

Sept. 9	.....	9	46.0	36.7	14.0	.....	2.7 gravel from .5″ to 2″ diameter.‡

RANGE No. 3.

Jan. 29	200.0	11	32.3	59.1	5.3	.....	1.7 clay in ellipsoidal forms 2″ to 3″ in diameter. 1.6 gravel from $\frac{1}{16}''$ to $\frac{1}{8}''$ in diameter.
Mar. 18	202.3	8	2.1	55.0	29.6	6.3	.4 clay. 6.6 gravel .1″ to .5″ in diameter.

RANGE No. 4.

June 3	184.5	9	17.0	51.3	22.2	5.5	4.0 gravel .1″ to .25″ diameter.
June 21	185.8	9	67.5	7.7	5.0	2.8	17.0 quartzite and fossiliferous gravel .5″ to 1.5″ diameter.§
Aug. 31	173.3	7	70.0	21.0	.....	4.0	5 0 gravel from .5″ to 2″ in diameter.
Sept. 25	.....	6	60.0	30.0	6.6	3.4	.....

RANGE No. 5.

June 3	184.5	8	44.0	36.3	16.0	2.5	1.2 gravel from .1″ to 1″ in diameter.
June 21	185.8	9	69.5	19.5	4.5	5.5	1.0 gravel from .1″ to 1″ in diameter.‖
Aug. 31	173.3	6	59.0	16.6	23.4	.....	1.0 gravel from .1″ to .5″ in diameter—some colored blue.¶
Sept. 24	.....	6	75.0	20.0	3.3	1.7	.....

† Ranges 2 and 23 the entire specimens were clay.
‡ Traces of lignite. 0.6 blue clay in spherical lumps .5″ to 2.5″ diameter.
§ Traces of mica.
‖ Traces of mica, mud, and blue clay. Sand in this specimen worn smooth.
¶ Traces of lignite. .05 of sand colored with iron oxide.

RANGE No 6.

Date.	Stage of river.	Number of specimens taken.	Per cent. of material in specimens, diameter to one inch.				
			1,000 to 100	100 to 50	50 to 25	25 to 10	Larger than .1 of one inch diameter.
1880.							
June 3	184.5	8	41.5	15.6	5.0	2.5	0.4 gravel from .1″ to 1″ in diameter.*
June 21	185.8	9	64.4	10.0	3.4	.....	11.1 gravel from .5″ to 1.5″ in diameter.† 11. blue clay.
Aug. 31	173.3	6	60.0	21.7	15.0	1.6	1.7 gravel from .1″ to 1″ in diameter.
Sept. 24	.....	6	66.6	30.0	3.4	.....	.....

RANGE No. 7.

Jan. 29	200.0	11	10.0	77.5	10.3	.....	2.0 gravel from .25″ to 1.5″ in diameter.‡
Mar. 18	202.3	9	57.4	28.6	5.8	4.3	3.3 gravel from .1″ to 1″ in diameter.‖
June 21	185.8	9	64.0	29.4	3.4	1.6	1.6 gravel from .1″ to 1″ in diameter.
Aug. 31	173.3	6	74.1	24.2	.....	.....	1.7 gravel from .1″ to 1′ in diameter.
Sept. 24	.....	6	75.0	20.0	1.6	1.7	1.7 gravel from .1″ to 5″ in diameter.

RANGE No. 13.

Jan. 29	200.0	11	31.9	48.4	19.3	.....	0.4 gravel .1″ to .75″ in diameter.
Mar. 19	202.4	9	6.9	66.6	17.8	5.0	3.7 gravel .1″ to .5″ in diameter.

RANGE No. 15.

Sept. 6	173.6	8	40.0	57.0	1.5	1.5	.....

RANGE No. 17.

Mar. 19	202.4	9	4.0	76.7	18.8	0.4	0.1 gravel, .1″ to .5″ in diameter.

RANGE No. 23.

Jan 29	200.0	7	59.1	34.8	6.1	.....	

RANGE No. 24.

Jan. 29	200.0	7	52.7	45.7	1.6	.....	
Mar. 19	202.4	9	3.8	60.0	26.1	8.3	1.8 gravel, from .1″ to .5″ in diameter.

RANGE No. 30.

June 4	184.4	9	7.5	56.2	30.5	5.5	1.5 gravel, one-tenth to one-third inch in diameter. 1.5 clay.

*One specimen blue clay with a little gravel.
†Traces of lignite.
‡0.2 clay in round balls.
‖0.1 clay. 0.5 lignite.

RANGE NO. 31.

Date.	Stage of river.	Number of specimens taken.	Per cent. of material in specimens, diameter to one inch.				
			1000 to 100	100 to 50	50 to 25	25 to 10	Larger than .1 of an inch diameter.
1880.							
June 4	184.4	9	57.4	23.9	7.0	9.5	2.2 gravel, from .1″ to 1″ in diameter.*

RANGE NO. 32.

June 4	184.4	9	82.2	11.1	3.1	0.9	2.7 gravel, from .2″ to 1″ in diameter.
July 12	193.9	7	83.7	13.6	2.1	0.6	

RANGE NO. 33.

June 4	184.4	9	73.3	18.3	3.4	5.0	
July 31	193.9	9	82.2	9.0	5.5	3.3	

* Traces of lignite.

The dredgings were generally taken on the line of one of the cross-section ranges. The different specimens obtained were distributed about equally in the width of the river. The percentages of the various sizes found in each specimen on the same cross-section have been aggregated and an average obtained by dividing by the number of specimens.

The coarse material on each section, sand and gravel, was found in the main channel and deepest water; the proportion of coarse and heavy material being much greater at low than at high water. Lumps of clay of spherical or ellipsoidal form were occasionally found at high stages, indicating that at high water this material to some extent is rolled or pushed along the bottom.

The character and distribution of the different material on the bottom, at extreme low water and extreme high water, have been compared by an examination of the cross-section soundings taken at the low-water survey, November, 1879, and the high-water survey, April, 1880. Thirty-three cross-sections, numbered from 1 to 33, have been taken in each case (see Plate I) covering the same part of the river. Of the 612 soundings taken at low water, 47 indicated, by casts of the lead, coarse sand and gravel, or 7.6 per cent. of the whole number; and of the 1,368 soundings taken at high water, 40 indicate the presence of coarse sand or gravel, which is only 2.9 per cent., showing that at low water there is a much larger quantity of gravel appearing on the river bottom. This has no doubt been transported at a higher stage, and as the river falls and the transporting power of the current becomes less it remains in the depressions in the river bottom at deep-water places, where it is found at low water, the lighter material with which it was accompanied being carried forward.

This distribution of coarse material at high and low water can be seen from an examination of the dredge specimens.

CAVING OF BANKS.

The most rapid rate of caving occurred along the reach when the river subsided after the high-water of May and July. It occurred to a less extent at both high and low water at places, but the maximum rate took place during the period the river was falling rapidly.

The principal point at which caving to any great extent occurred was on the left bank between ranges 8 and 11. (See Plate I.) This caving occurred at both high and low water stage, occasioned by the gradual enlargement of the channel on the left of the middle bar, a constant erosion taking place on account of the impingement of the current on the bank at all stages. This caving extended a distance of 3,800 feet, and from November, 1879, to May, 1880, the caving had, along this distance, averaged 125 feet.

The caving that occurred between ranges 18 and 23 on the left bank was principally due to a similar cause, viz, the gradual enlargement of the chute.

At high and medium stages the bank was rapidly eroded by the increased volume of water discharging through the chute. The width of the chute increased from 1,340 feet to 1,650 feet, from November, 1879, to May, 1880, the caving extending back an average of 102 feet.

The greatest amount of caving on the reach occurred between ranges 23 and 26 on the right bank, covering a distance of 5,000 feet and extending back an average of 175 feet.

Slight caving occurred at other points, but not of sufficient importance to be considered.

The maximum rate at all these localities occurring during the rapid fall from the high stage that the river attained May 18 and June 15, 1880.

No caving of any amount occurred during the season in front of the town of Lake Providence. The channel leaves the right bank, the main portion going to the left of the middle bar.

OFFICE WORK.

Number of maps plotted 118
Number of tracings made 118

Very respectfully submitted.

ARTHUR HIDER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Corps of Engineers U. S. A., Secretary Mississippi River Commission.

APPENDIX E.

A REPORT BY THE SECRETARY OF THE COMMISSION UPON OBSERVATIONS AT CAR ROLLTON, LA., DECEMBER, 1879, TO OCTOBER, 1880.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July, 1882.

GENERAL: I have the honor to submit the following report upon the observations, conducted by the party of Assistant W. H. Williams, at Carrollton, La., from December, 1879, to October, 1880.

The general history and description of the work are compiled from the reports and diagrams forwarded by the chief of party during the progress of the work. The description of methods employed is based upon the instructions and reports, supplemented by a memorandum prepared by Assistant Hunter Stewart, who was a member of the party. Important information under both the heads has been received from Assistants L. C. Jones and J. C. Cammack, who were also of the party.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary Mississippi River Commission.

General C. B. COMSTOCK,
Chairman of Committee on Surveys and Examinations.

REPORT.

I.—GENERAL DESCRIPTION AND HISTORY OF THE WORK.

The observations were taken above, at, and below Nine-Mile Point or Diamond Bend, a short distance above New Orleans, and about one hundred miles above the Gulf.

The Mississippi River, in this portion of its course, is characterized by very short, sharp curves, connected by straight reaches of unusual length. Its width, averaging about 2,300 feet, is much less, and more uniform, than it is at points above; and the mean depths are correspondingly greater. The latter are by no means uniform, however, the variations being nearly, if not quite, as great as between Cairo and Memphis. The banks are comparatively stable, and are raised above the level of the highest floods by levees, which run on both sides close to and mainly parallel with the high-water lines. The oscillation is about 16 feet, or less than one-third of that at Cairo, Vicksburg, or Natchez. The slope is at all times exceedingly small, although the range of its variations is considerable. The range of mean velocity does not differ greatly from that at other points, being only a trifle less than that noted at Fulton, 60 miles above Memphis, during the same period. The range of

discharge is still less, since the changes of area are, on account of the smaller width and oscillation, considerably less. The variations of all the elements of the regimen are, moreover, less frequent and violent than in the upper portion of the river.

The observations consisted of the remeasurement of selected cross-sections at frequent intervals; of occasional longitudinal lines; of dredgings to determine the material composing the surface of the bed; of transverse velocity measurements, and of frequent determinations of discharge, slope, and sediment in suspension. In May, 1880, the programme was modified by the discontinuance of the cross-sections as an independent branch of the work; and by greatly elaborating the longitudinals, which were taken at all bases instead of one, and in ten lines instead of four. The cross-sections were determined, secondarily, by placing a sounding of each longitudinal on each range which it crossed. The discharge and sediment observations were given greater prominence than before.

Figure 1, Plate I, is a map of the locality. On it are shown the locations of the ranges, the approximate distribution of the longitudinal lines and of velocity floats, and the positions of the sediment observations and dredgings.

The cross-sections, nine in number, are in groups of three, known as the Labarre, the Diamond, and the Cambronne sections. Over the middle section of the most northerly, or Labarre sections, the velocity floats were run. As nearly as can now be ascertained, the first, second, and third Cambronne sections correspond to sections numbered 72, 77, and 82 of the Delta survey of 1851–'59, and the second or middle Diamond section to No. 59 of that survey. No sections were taken by Humphreys and Abbot in the immediate vicinity of Labarre base.

The Labarre cross-sections were sounded on December 6 and 26, 1879, January 9–10, 23–26, February 9–13, March 2–5, 11–19, 30–April 6, and April 30, 1880. Longitudinal lines were then run at this base on May 19 and 31, June 10, 17, and 25, July 7 and 23, August 3, 14, 23, and 28, and September 16 and 29, 1880. Four longitudinal lines were run at this base on December 10 and 31, 1879; January 15 and 27, February 14, March 3 and 13, April, 6 and May 3, 1880. Cross-sections were sounded at Diamond base on December 3 and 25, 1879; January 10–15, 22–23, and 30, March 1–2, 12–13, and 29, April 12–13, and May 1, 1880. Longitudinal surveys were then made on June 9, July 7 and 20, August 2, 11–12, 21, and 26, and September 14 and 23, 1880. At Cambronne base cross-section surveys were made on December 2 and 22, 1879; January 7–9 and 20, February 7 and 20, March 10 and 31, and April 6–10 and 28, 1880. Longitudinal surveys were made on May 17 and 26, June 8, 15, and 23, July 1 and 15, August 7 and 19, September 2 and 20, and October 7, 1880.

The discharge was measured on December 17, 1879; January 3, 16, and 26, February 13, March 5 and 18, April 1, May 21, June 1, 12, 16, 19, 24, and 29, July 2, 8, 16, 24, and 31, August 5, 9, 16, 20, 24, and 27, September 3, 13, 18, 21, and 30, and October 1 and 8, 1880.

Sediment specimens were obtained in December twice; February, March, and April once each; in May twice; in June and July five times each; in August six times; in September five times, and in October once.

Slope was measured on January 19 and 28, February 17, March 23, May 6 and 24, June 3, 14, and 25, July 3 and 26, August 6, 17, and 25, September 4 and October 1, 1880.

Dredgings were made at Cambronne base March 16, and at Diamond and Labarre bases March 20, 1880.

Transverse velocity curves were determined at Labarre base on January 5, March 24, July 12, and October 4, 1880; at Diamond base on January 6, March 25, July 13, and October 5 and 13, 1880, and at Cambronne base on January 5, March 26, July 14, and October 6, 1880.

The party for this work consisted of one assistant engineer, three recorders, three rodmen, one leadsman, five boatmen, and the crew of a small steam launch. With the abandonment of the cross-section surveys, the use of the launch was discontinued, and a slight addition made to the laboring force at such times as circumstances made it necessary.

II.—DESCRIPTION OF METHODS.

Cross-section soundings.—The position of each sounding was determined by intersections from two transit instruments, one at each end of the "base" corresponding to the ranges to be sounded. The ranges were permanently marked by stakes which had holes bored vertically in their tops to receive movable flags. The range to be sounded was designated by two flags on each side of the river, one being planted in the permanent stake on the levee, and the other in the ground at the water's edge and carefully lined on the range. These inner flags were always located by the instruments, and their positions recorded as those of the first and last soundings, each with a depth zero.

The lead-lines used were of $\frac{1}{4}$-inch sea-grass rope, every tenth foot being marked with a leather tag, and the other feet with differently colored strips of flannel, the accuracy of the divisions being frequently tested, and soundings corrected for any

change noted. The weight of the lead used was 12 pounds, and the character of the bottom was obtained at every sounding, the lead being primed with tallow for that purpose. Soundings were taken either from the launch or from the skiff, the party consisting, in addition to the crew, of a rodman in charge, who acted as a recorder of soundings, and a leadsman.

The boat was signaled up and down stream by a flagman stationed at the shore flag; he directing the boat a sufficient distance above the line, so that it would acquire, by drifting back, such velocity as would prevent the head-line from sagging. The leadsman was stationed in the bow of the boat, where there was a mast or staff with a flag so rigged that the steersman could raise or lower it instantaneously. When the boat passed the cross-section line going up stream, this flag was raised and the transitmen brought their instruments to bear upon it, keeping their vertical wires upon the mast as near its intersection with the deck as possible. The boat continued up stream until the flagman on shore signaled to sound. It was then allowed to drift astern, the leadsman heaving the lead as soon as the headway was lost and raising or lowering the lead so as to have it on the bottom and to keep the line plumb. An instant before the boat crossed the line going down stream the flagman on shore signaled; the recorder called out "sound;" the leadsman gave the reading on his line; the steersman let the flag drop, and the transitmen read their angles.

Longitudinal soundings.—For this work two additional ranges were located at each base, one 1,000 feet above, and the other the same distance below the middle range. At the middle of each base oblique ranges were laid off to intersect the uppermost of the new ranges in ten selected positions.

The positions assigned to the party were the same as in the cross-section surveys, with the exception of the flagman on shore, whose duty consisted in changing the flags on the oblique ranges and in signaling the boat when it approached and when it crossed the middle range.

Soundings were taken mainly from the skiff and while it was drifting astern, the velocity being so regulated that the lead-line could be kept plumb. The boat having been run into position, obtained by the steersman from the intersection of the range signals, was rowed up stream a sufficient distance to obtain a vertical sounding by the time it had drifted back to the upper or zero range. As soon as the boat was in position, the flag was raised, and when the uppermost range was crossed going down stream it was dropped. Between ranges the flag was raised at every fifth and dropped at every tenth sounding. As the boat approached one of the old cross-section lines, the steersman was signaled and raised the flag; when the leadsman was on the line he was again signaled and dropped it. At each end of the base this was determined by the observer setting his instrument on line and giving the requisite signals, and at the middle range by the flagman "lining in." The paths of the boat were located from the same base as was used in cross-section surveys. The shore flags were placed and located as before, thus giving cross-sections of twelve located soundings.

No attempt was made to follow the same path on different surveys; it was only at the initial points that endeavors were made to obtain the same position. After starting on a line the boat was left entirely to the effect of the current and wind, the velocity alone being regulated so as to get vertical soundings.

As many as five hundred soundings were taken on one line when the current was slack; but, after receiving instructions to that effect, the number was limited to two hundred, and this latter number was about the average.

Leads of various shapes and different weights were used, varying from the large mushroom-shaped to the ordinary twelve-pound lead. For a medium current, the latter was found to give the most satisfactory results, and towards the end of the work it was used to the exclusion of the others.

The soundings were, probably, as a rule, in excess of the true depths, and this excess should increase with the stage of the water. The difference, however, between the measured values of two consecutive cross or longitudinal profiles, in the same position, would differ but little from the true difference between the actual profiles. The absolute area is in question only in the discharge observations, where, as will be seen later, probable errors from this source are unimportant.

Velocity measurements.—The discharge section was No. 2 of Labarre base. One hundred feet above and below it, auxiliary ranges were located for determining the paths of the floats. At the intersection of each of the three ranges with the Labarre base, an observer was stationed with a transit. The three stations were connected by a telegraph line, and each observer was furnished with a key for giving and a sounder for receiving signals. The velocity was measured by double floats run at mid-depth. The floats were exactly like those used at Fulton, Tennessee, during the same period, and fully described in the report of Assistant W. H. Powless, of July 11, 1881.* The copper connecting wire was, in the most of the work, replaced by a small fishing line, said to be but little larger. The floats were launched and recovered by

* Printed as Appendix D to Report of Miss. River Com., 1881. Sen. Ex. Doc. No. 10, 47 Cong., 1st Sess.

a skiff party in charge of a rodman. The skiff, after the float was put out, followed its path as closely as possible and sounded that portion of it between the first and second ranges. The boat was placed in position as for longitudinal soundings already described. The rodman in charge of the skiff party noted and recorded the exact time that each float was launched. Subsequently a second skiff party was organized, and the first one remained above the ranges and launched the floats while the second picked them up below. The soundings in the path of the float were discontinued, and a special sounding of the discharge section substituted. The duties of the transitmen during the run of the float were as follows: Number one signaled to two and three when the float crossed his range, and recorded the time of crossing. He then read angles to the float at signals from two and three. Number two started two stop-watches when he received the signal from one. He signalled the crossing of his range to one and three, and at the same time stopped one of the watches and recorded its reading. He stopped the second watch on receiving a signal from number three and recorded its reading. Number three read angles to the float on receiving signals from one and two, and signaled to both of them the crossing of his own range. The stop-watches and those of the rodman on the river and transitman number one were compared before and after each set of observations. The stop-watches beat fifths of seconds. Each series consisted of from 21 to 26 floats.

The velocity determined from the run of any float would be equally affected by the same percentage of error in the observed time of transit or the length of the path. The latter could be appreciably in error only from failure of one or both observers to point the telescope correctly on the range. The instruments were set on a signal on the opposite side of the river, and the setting at such a distance could easily be made within three inches, or one and a half inches on either side of the true position. This would give a maximum error from this source of 3 inches in 200 feet, or 1 in 800. Since this error is proportional to the distance from the instrument, it could not exceed in an average of floats distributed over the river, one-half the above amount, which would not be appreciable in the second place of decimals. Errors in the observed time of transit may, considering the appliances furnished, be safely assumed not to exceed one-half a second, which in an average run of 50 seconds would be one in one hundred. The velocity of any float may therefore be taken as true within one per cent. The resulting discharges cannot, however, be accepted as possessing this refinement, for in reduction the velocity so measured must be assumed as the mean velocity through a considerable portion of the cross-section, amounting often to thousands of square feet. In a series of double floats run in rapid succession, at the same depth and over the same path, the individual results have been observed to vary by as much as 25 per cent. The velocity of a single float may by accident be the average velocity for that portion of the stream, but in general it will not; and, however exactly it may be measured, it cannot be accepted as more than an approximation to the quantity desired. Add to this the error in determining the cross-section, and the uncertainty as to whether the section measured is the really effective one, and it seems improbable that these discharges can be relied upon within 10 per cent.

Transverse velocity curves.—Rods 3 inches in diameter were weighted so as to float upright, and with an immersion of 6 feet; they had a projection above the surface of the water 1 foot long and 1 inch in diameter, upon which a flag was placed. Twenty-one of these floats were run at each base. Locations were made and intervals of time obtained in the same manner as for discharge.

Slope.—Opposite each point where the elevation of the water surface was to be taken a post was firmly planted on the levee. The elevation of each of these posts, with the exception of the one at Millandon Station, was determined by precise levels, run by Mr. Braid, assistant, Coast and Geodetic Survey.

When an observation for slope was to be made one man was stationed at each of the following places: Millandon, the upper end of Cambronne base, the upper end of Diamond base, Station No. 7 of the 9,000 feet stretch, Station No. 4, and Station No. 0 of the same. At a given time, the watches having been compared, or at an agreed signal, such as the blowing of the 12 m. whistle of one of the mills in the vicinity, each man would drive his stake to the water's edge, the one at Station No. 7 driving Nos. 8 and 9 as soon thereafter as possible; the one at Station No. 4 doing likewise at Nos. 5 and 6, and the one at Station No. 0, at 1, 2 and 3.

The stakes were made of ash and had a bench cut into them, the surface of which was driven to the water's edge. The stakes faced the shore.

The leveler who was at Station No. 0, upon the return of the boatman, would commence to connect the benches of the slope stakes with the stubs, which, at each point, could be done generally with one, and never more than two, settings of the level.

Sediment.—Samples were taken and combined as fully described in the report of Assistant Powless, already referred to. During the first part of the work the slip-bottle used was constructed on the same principle as that described by Assistant Powless, but had two chambers, each of 2 ounces capacity, so that the entire sample ob-

tained was preserved. Later this was lost and a trap-bucket of the ordinary form was substituted.

Dredgings.—Specimens were taken with a dredge-bucket of the pattern described by Mr. Powless in the report before mentioned. An analysis or description by the assistant in charge indicates that no classificaton by sizes was practicable. The material was entirely fine sand, clay, and lignite.

Reductions.—All notes were consolidated upon blank forms supplied for the purpose, and sent to the office in Saint Louis for reduction. Soundings were platted in the form of cross or longitudinal profiles, the scale being generally 1 inch to 200 feet horizontally, and 1 inch to 30 feet vertically. In constructing the longitudinal profiles, the located soundings, about 1 in 10, were platted in their determined positions, and those laken between any two of these, were uniformly distributed over the corresponding distance. A line was drawn to show the position of the surface at the time the sounding were taken. On the platted cross-sections the water's surface was indicated, and also a line parallel to it and at the elevation of the zero of the Carrollton gauge. The methods of determining discharge and sediment are correctly described by Mr. Powless, except that in allotting the partial areas the computer followed, not his judgment, but the *rule* that the mean depths of the partial areas should be in the same ratio as the corresponding velocities. Two independent computations of discharge were made.

III.—DISCUSSION OF RESULTS.

1.—The discharge; its relation to the gague; to the slope. The mean velocity. 2.—The sediment in suspension. 3.—The movement of the bottom. 4.—Changes in channel capacity.

1.—*The discharge; its relation to the gauge.*—The methods of measuring the discharge and the probable accuracy of the results have already been given in detail. The cubic discharge per second and the corresponding gauge readings have been plotted as co-ordinates on Plate II, Fig. 1. The curved line drawn among the points has no mathematical basis, and is merely intended to indicate that some general relation subsists among the quantities observed, without attempting to define what that relation may be.

If the points on the line be assumed to represent the true discharge for corresponding gauge-readings, the greatest discrepancy between any discharge so assumed and the discharge at the same gauge as deduced from direct observations is, with three exceptions which will be mentioned later, less than 60,000 cubic feet in 660,000, or less than 9 per cent. (No. 19). A curve of no more complex form than that shown might be determined, which would reduce this discrepancy. An error of 9 per cent. in estimating a discharge is not only of no consequence in any application of that quantity in a practical problem, but it is less than the *possible*, and but little greater than the *probable*, error of any single discharge measurement by the method here used. While it is not assumed that if other discharges had been measured none of them would have departed more than 9 per cent. from this line, it is believed that during the period covered by the measurements plotted, the line represents a relation between discharge and gauge which is not seriously in error, and that for any gauge-reading the discharge as measured is probably *no nearer the truth* than that taken from the line.

The three exceptions mentioned above are the first three observations of the season. They plat on a curve nearly parallel to the first, but at some distance below it. They comprise all the determinations made during the first rise after the low-water season. They indicate for the same gauge discharges nearly 100,000 cubic feet per second greater than the rest of the measurements. This can scarcely be a coincidence of errors, but is very probably a close approximation to the true state of affairs. Various categories were applied to the observations, but none of them, whether as to high or low stage, rising or falling river, larger or smaller area, or scouring or filling bed, would classify any of the other observations with these three, nor make any greater conformity to law apparent. The two curves may be taken as representing the relation between gauge and discharge for the entire period of the observations, and in computing the mean monthly and annual discharges they have been so taken. To make them continuous there is for the upper end no other guide than the curve joining the third and fourth discharges on Plate VIII. This curve calls for a slight increase of discharge after the third observation, followed by a stationary and then decreasing discharge, all for a steadily rising gauge. The line joining the third and fourth observations, Plate II, represents a similar relation. The method of connecting the lower ends of the curves will be explained subsequently in discussing the subject of channel capacity.

Relation of discharge and slope.— Slope Stations 0–9 were established for the purpose of obtaining the slope, considered as an element of the regimen. The other stations were for obtaining other information concerning relative surface heights. That at Diamond base was in a powerful eddy, and was set for the purpose of observing the effect of this eddy. The discussion is based on the results at the upper nine, or

regular, stations. The various profiles of water surface determined by the slopeboservations are plotted in their relative positions in Fig. 1, Plate III. They may be classified as high stage (above 10′ of the gauge), mean stage (10′ to 5′), and low stage (below 5′). The means of these classes are plotted to a larger scale in Fig. 2, same plate. Table 2 gives the figures from which these means are made up, and shows that they represent typical profiles and not the accidental summation of discordant resnlts. Within the limits of such work, the measurements seem to have been very well taken.

The lack of uniformity in the fall of the water surface is apparent from the profiles; but the most striking feature which they present is the existence at several points of *reverse* slopes. These reverse slopes occur persistently in the three profiles, at Stations 2, 4, 7, and 9 (No. 9 = Labarre base). At Station 10 (Diamond base) reverse slope appears at high and mean stages, but disappears at low stage. At Stations 2, 4, 7, and 9, with the single exception of the low-water point at Station 1, these reverse slopes are greatest at low and least at high water. The first explanation which suggests itself is that they are due to eddies. The configuration of the river and the location of the channel favor this view (see Plate I). The river is here much above its average width, and the current coming out of the bend above is presumably on the side opposite the slope stakes, and of great force. But it is scarcely possible that the effect of an eddy should increase as the river falls. Eddies are usually, if not universally, high-water phenomena. Some of the most important which have come under direct observation, disappear at low stage. It seems probable that in all cases their velocity and presumably their effect in raising or depressing the surface, will increase and decrease with the mean velocity of the river. The results obtained at Diamond base, from the stake set in the eddy, support this view. The instructions for the work explicitly state that slope stakes must be driven as nearly as possible at points of equal velocity, and "especially not in or near eddies." The improbability of this caution having been overlooked or systematically disregarded, establishes a strong presumption that the reverse slopes are not the results of eddies. But if it is admitted that the water in which these stakes were set was moving *down stream*, while at the same time its surface inclination was *upstream*, it must also be conceded that the momentum of the moving water enters as a factor in determining the conditions of its flow; and hence, no exact relation necessarily, or probably, exists in natural channels, between the velocity of the water at a particular time and place and the local slope of its surface at the same time and place. This principle may be applied to the sectional areas as well. By the term *local slope* is meant the fall of the water surface which would result from a measurement made over a *very short*, or relatively *infinitesimal* length. Such measurement is in the nature of things impossible, and the quantities here discussed are not strictly *local slopes;* but the argument turns on the *existence* of *reverse* slopes, which being demonstrated for *any distance*, it follows, from the continuity of the surface, that reverse slopes must exist over infinitesimal distances at numerous points between those determined.

If *local* slope be rejected, it follows that an average fall over an assumed distance, greater or less, must be taken as representing the slope which determines the discharge. That distance must, of course, be greater than any which has been found to give reverse slopes. It must be such that the results which it gives will agree among themselves, that agreement consisting generally in a direct (not necessarily constant) ratio between the slope and the gauge reading. For the extremities of the slope length should be so taken as to be free from local complications, which produce elevations of surface quite out of register with the corresponding velocities. If so taken, the oscillation (for this part of the river) will be greater at the upper end, and, in order that the surface remain continuous, the average fall between the two must increase as the river rises. As the selection of points free from such complications would be a difficult task, the distance should be increased to such extent that errors from this cause, by being distributed over a greater length, will affect the result but little. The effective slope might probably be well determined by taking the difference between the means of the elevations of the surface on each side of the river in two successive bends.

The distance over which these slope observations were taken is, with one exception, about 5¾ miles. In reducing the work the average fall over the entire distance was taken to be the "slope." The quantities thus determined are plotted as co-ordinates to the corresponding gauge readings in Fig. 3, Plate III. The plotted points show a very close relation between the gauge and slope at mean stages of the river, the relation changing, however, at high, and reversing at low water. Both discrepancies can be plausibly explained from the location of the extreme stakes. The upper stake (see Plate I) was driven in a wide river, on the side opposite the channel, where the surface elevation at high water was probably *below*, but could not have been *above*, the true level for that section. The lower stake was driven on the channel side, immediately below a sharp bend, where the high water elevation (see also the high-water profiles, Plate III) could not have been *below*, and was very probably *above*, the true

level for that section. The local effects at both extremities would combine to reduce the measured fall at high water. An error of one-tenth of a foot from these two sources would, if corrected, bring the high water observations into accord with those at mean stage. The excessive fall at low water is plainly due (see mean low-water profile, Plate III) to the abnormal local elevation at Stations 0, 1, and 2. It seems probable that a more fortunate location of the extreme stakes would have given slopes at all stages, agreeing in the main with those observed at mean stage, and that the latter most nearly represent the relation between the gauge and the effective slope.

The inclined line in Fig. 3, Plate III, represents the relation between any reading of the Carrollton gauge and the slope which would be determined by the elevation and distance of the water surface, at that reading, above the Gulf level. (This line is determined as well as can be done from present data.) It corresponds so nearly with the relation of the mean stage observations as to justify the suggestion that effective slopes might be computed from the gauge readings as accurately as from direct measurements.

No attempt has been made to establish any relation between the observed slopes and the discharges.

The mean velocity.—The mean velocity, or the result obtained by dividing the computed discharge by the sectional area, is a mean of the observed velocities (supposing them equidistant, as they practically are), when each is weighted according to the depth at the point where it was observed. Hence, any change in sectional area, so distributed as not to change the relative depths, will not affect the mean velocity, for any given series of observed velocities. Any discrepancies in the discharges, from the use of improper or incorrect areas, may, therefore, be expected to disappear in a comparison of the mean velocities. Should the mean velocities present discrepancies similar in kind and amount to those of the corresponding discharges, the presumption would be strong that errors in the discharge introduced through the areas are unimportant.

The mean velocities and the corresponding gauge heights are plotted as co-ordinates in Fig. 2, Plate II. A glance at the diagram is sufficient to show that none of the discrepancies in the discharges have disappeared, and very few of them have been materially reduced. The correspondence of the first three observations is particularly noticeable, showing conclusively that the conditions represented in the discharge curve were real.

The total range of water area, from the highest to the lowest observed discharge, including changes both at surface and bottom, was 21 per cent. of its mean value. The range which would have resulted from the change of surface, supposing the bottom to remain fixed in its first observed position, is 20 per cent. of the mean value. The maximum change in the datum section was 19,000 feet. Supposing the minimum water area to have been in error by this entire amount, the resulting discharge would have been changed by 15 per cent. only. This is the maximum error which could have resulted from sounding the section at any time during the season and adopting that value for the whole work.

The comparative independence of mean velocity and area also appears from Fig. 3, Plate II. The points plotted have for their co-ordinates the discharge and the mean velocity. If the area were *constant* the locus of these points would be a straight line, and the constant area would be represented by the inclination of the line. The full line fairly represents the mean locus of a majority of the points. Its curvature indicates an increase of the area with the discharge, which is, in general, to be expected. The broken line drawn near it represents the law of increase of the discharge section from the rise of the surface alone (2,500 square feet for one foot rise). Observations 3 to 8, inclusive, show plainly the effect of increase of area at the bottom. Its maximum (observation 5) is 65,000 cubic feet in a discharge of 700,000, or about 9 per cent.

The irregularities in the mean velocity and discharge are then mainly due to variations of the observed velocities. How much of these is attributable to changes in actual velocities, and how much to errors of observation, cannot well be determined. Considering the probable error of a single observation, and the further probability that any determination, even if correctly made, might differ largely from a fair average for that position, together with the fact that a comparatively small number of observations, varying from day to day in number and position, must be depended upon to determine the average value of a quantity, which at any instant conforms to no known law of change, the work might still be called good, after it had been demonstated that its mean error was as great as the total discrepancies of these observations.

On the contrary, the observations show conclusively that the discharge varies materially for the same gauge reading, and it must be conceded that causes which could produce so great a change at one time would not be entirely inoperative at all other times. It seems justifiable to reaffirm the conclusion already reached—that the mean

line represents the relation of discharge and gauge *as nearly as do the observations* themselves.

If the conditions represented by these observations could be shown to recur (even approximately) from year to year, the determination of the discharge of the river from the gauge reading at any time in the future would be entirely practicable, within the limits of needful accuracy. This recurrence is indicated by numerous circumstances, but can only be demonstrated by direct observation.

The observed, mean monthly, and mean annual discharges and gauge heights are given in Tables 1 and 2.

2. *Sediment in suspension.*—The detailed results of sediment observations are given in Table 1. The quantities of surface, mid-depth, bottom and mean sediment, and its ratio by weight to water, are plotted on Plate VIII.

The means of the results obtained at different positions in the width of the river, as shown by the "vertical combination," are sensibly equal, showing a uniform distribution from side to side. The means of the surface, mid-depth, and bottom observations are in the ratio of the numbers 100, 144, and 183, respectively. This relation cannot be said to be generally true of the individual observations. A majority of them show the least sediment at the surface and the most at the bottom; but the ratios, both at low and high stages, are greater than the above, while at medium stages, and particularly when the action at the bottom is slight, the amounts of sediment at different depths become more nearly equal. In one case (May 22) the bottom sediment is the least, and in two other cases (June 30 and July 8) it is less than the mid-depth. In all of these cases there was little or no action at the bottom.

Moderate change at the bottom, either by scour or filling, is generally accompanied by increase of bottom sediment, while if the action is intense the mid-depth is also affected. The surface sediment shows no changes which can be referred to change of stage. It is nearly constant from the beginning of the observations until the end of June, when the third rise begins. This rise, coming from the Missouri River, gives, not only an increase of saturation, but an actual discharge of sediment nearly equal to the maximum, and greater than that which accompanied the maximum discharge of water.

From these indications the sediment may be classified as permanently or intermittently in suspension. The amount of the former at any given time will depend almost wholly upon the proportion of the river's discharge which has been contributed by the Missouri River. The amount of the latter will depend upon the extent and violence of the local action in the vicinity. Its presence in the water must be due to scour, and therefore the presence of large quantities of sediment, especially at the bottom and mid-depth, at localities where filling is going on, is a strong indication that the fill observed is not general, but is accompanied by scour at neighboring points. This indication becomes a certainty when the sediment is found to *increase* while the fill progresses.

Whenever the contribution of water from the Missouri River is insignificant, the variations of the amount of sediment in suspension are an index, more reliable perhaps than any other, of the general action going on in the bottom of the stream. The variation at the bottom would indicate the action in the immediate vicinity; that at mid-depth the prevailing action for a distance, more or less, above the point of observation; while that at the surface would indicate the prevailing action for a still greater distance up stream.

3. *Transportation of material by movement on the bottom.*—One object of the longitudinal soundings already described, was to detect any progressive motion of the irregularities of the bottom; and, if detected, to measure, if possible, the amount of material so transported.

That the well known behavior of shifting sand under the action of wind, and in the beds of clear, shallow streams, is repeated on a much larger scale at the bottom of the Mississippi, is a reasonable proposition. The forms assumed by the sand under such conditions are well described by the term "waves," usually applied to them. It is conceived that waves may be formed in this manner; on a smooth, flat bottom the action of the current would carry along a film or stratum of material, only partially supported by the water and resting with part of its weight on the bottom itself. Equality of resistance at all points is impossible, and an excess at some point causes the formation of a small lump or mound by the stoppage and accumulation of material. This mound is built to greater dimensions, and is extended up stream in a long, flat slope. At a certain angle of this slope the resistance is sufficiently decreased to allow the material, instead of being stopped, to be slowly pushed or rolled up the slope, until it reaches the crest, or point of original obstruction, when it falls over, and being in a measure protected from the current, remains. Thus a portion of the material rolled up to the crest is engaged in building out the steep front slope, and the front of the wave progresses down stream. As the front progresses, the height remaining the same, the slope is flattened until it becomes possible for the current to

move the material forming the up-stream portion of the wave, which follows the crest down stream, thus giving a motion to the entire wave.

This idea of the typical form of the wave enables some phenomena of common observation to be recognized as the results of wave action. Such are the shoals themselves, which in every case present a long approach of gentle slope to a crest from which the bottom abruptly descends to a considerable depth. The surfaces of bars, recently exposed by the falling water, are seen to be covered with innumerable waves of similar form but smaller dimensions. Sometimes these may be resolved into two or more systems, each larger than the last, the whole finally passing into one huge wave which is the bar itself.

This theory of wave action, which is so rational, conforms so closely to the observed action of clear-water streams, and explains so satisfactorily the similar phenomena presented by the river itself, carries with it, if adopted, certain restrictions which must not be lost sight of in discussing observations of this character. The most important of these, and the only one to which allusion will here be made, is that wave action cannot, unaided, produce a form which differs widely from the type above described.

In reducing the longitudinal soundings, the positions of the various lines for each survey, together with the profiles, were plotted and traced. In comparing the various surveys, the positions and directions of the lines were first examined and each profile was then studied, its characteristics, with the number and dimensions of waves, if any, being noted. The plat of the next survey was then superposed, and the lines which were most nearly identical in position were noted. The corresponding profiles were then compared. Notes were taken of the general action, whether of scour or fill; of the changes in the general features of the profile; of the possible or probable identity of waves in the two lines; and of the apparent motion of identified waves, as well as that of the profile as a whole.

The existence of wave forms would be conclusively proven by these observations, were they the first and only ones of their kind. A more perfect series than that shown in the profile of the second line, survey of April 6th, 1880 (Plate IV), could scarcely be desired. It may be stated, however, that no other of the profiles approaches this regularity. The waves there shown are the largest observed, and as the conditions under which they were formed are plainly those most favorable to wave development, they will be discussed in some detail.

At the date of the observation (April 6), the river was in the main stationary, and, though not at the highest stand, was at its maximum of discharge and velocity. The line in question was run at a distance of about 1,200 feet from the left bank, or nearly at the middle of the river. It ran along a ridge or "middle ground," which was at the time the locus of a heavy fill. Of the three other profiles of the same date, the third shows two tolerably good waves and a trace of a third; the first shows a perfectly smooth bottom; while the fourth, near the right bank, is so crooked as to be useless for comparison. The quantity of sediment in suspension greatly diminished between the observations of March 19 and April 9. The survey of May 3 shows the fill still progressing, with the two upper waves of April 6 replaced by a single one of less height, another wave of similar size being indicated below. This wave is plainly shown in the same position in the next survey (May 19). From this date to the close of the work a general tendency to motion down stream is discernible, but the forms of the waves undergo great modifications, and in some cases are probably obliterated and replaced between observations.

The above gives an idea of the significance of the observations in an extreme case, as well as the method in which all have been treated.

The discussion is much restricted from the fact that no longitudinal soundings were made at Diamond and Cambronne during the high-water period, which appears from the Labarre profiles to have been that of greatest activity in the formation of sand waves.

Waves are formed at localities where a fill is in progress, and rarely elsewhere.

The changes at the bottom were the greatest at Labarre, and the least at Cambronne. For frequency and dimensions of waves observed the localities stand in the same order. At Labarre two profiles, side by side, rarely give the same indications, or show the same waves; while at Diamond and Cambronne a prominent feature of any profile is generally recognizable in those on either side of it. At Labarre the character of the local action changes much more frequently in the same cross-section than at Diamond or Cambronne. At Labarre, in the profiles of December 10 and 30, and January 15 and 27, the central lines 2 and 3, where a constant fill was in progress, show a series of waves gradually forming and increasing; while the first line, where a gradual scour took place, and the fourth line, where no change occurred, show no waves; or at best if the few irregularities be called waves, they are trifling in effect when compared with the others. In the profiles of February 14, these waves have entirely disappeared. At about this time the cross-sections show that the general action on the Labarre sections changed from a scour to a fill, and there was probably a short time when the bottom was stationary. In the profiles of March 3, waves again make their appear-

ance on the upper half of the third line, between ranges 1 and 2. The cross sections, March 2 and 5, show on sections 1 and 2 a fill at the locality of the third line. Section 3 does not show this fill. In the profiles of March 13, the series of waves has extended over the whole of the third line, some of the waves having increased in size, and the fourth line is also slightly involved. The nearest cross-sections, March 9, show a slight fill in the part corresponding to the third and fourth lines, the general action of the sections at the same date being a slight scour. The profiles of April 6, which have already been described, and in which the observed wave formation culminates, follow the same rule. Further details are unnecessary. The occurrence of waves in connection with fill on the bottom, and their diminution or disappearance at other times, are shown with great persistency in all the profiles.

The forms and dimensions of the waves appear to depend upon the rate of deposit and the velocity of the water. As to the forms of the waves, the most noticeable fact is that steep front slopes occur only when the velocity is much above the average. With the same supply of material, the diminution of velocity is accompanied by a lengthening of the waves, with, generally, a reduction of height. An increase of material tends to increase the lengths of the waves, and an increase of velocity to increase their heights. These effects all relate to the *formation* of the waves. Their destruction is much more rapid and erratic. It has not been observed in enough progressive stages to warrant any further deductions.

The investigation of the amount of material passing down the river in the form of sand waves, was begun by an approximate determination of its maximum, which was found to be so small in comparison with the amount carried in suspension that the subject was not pursued further. The maximum wave observed was 15 feet in extreme height. It extended over not more than 1,000 feet in the width of the river. It was so nearly triangular in shape, that half the extreme height, or 7½ feet, may be taken as the average. Its motion is a matter of great uncertainty. If the testimony of two or three cases of very doubtful identification of waves of the same period be admitted, a motion of about 15 to 25 feet per day can be made out. This accords well with determined rates at lower stages, as also with those of observations at other localities. A daily motion of 100 feet, which is plainly excessive, will be assumed, and on this basis the material transported amounts to 750,000 cubic feet per day, or about 2 per cent. of that carried in suspension on the same day. The observations show that action of this character is quite insignificant in amount during a large portion of the year, probably nine out of twelve months. If the action be assumed to be maintained at the above extravagant rate during the months of February, March, and April, in which months about 40 per cent. of the annual discharge of sediment in suspension takes place, the yearly discharge of material in sand waves would be eight-tenths of 1 per cent. of that in suspension. It is believed that the above estimate has been so liberally made that the percentage given may be safely taken as an outside figure for the entire amount of material moved by the stream, over and above the amount indicated by the ordinary observations for sediment in suspension.

Several considerations make it improbable that any great amount of material is transported in a rapid and continuously moving stratum near the bottom. The dredgings of the bottom show that only the merest trace of the material composing the bed is such as might not be readily taken in suspension and carried to the surface. No stratum of this nature could be compact enough to stop the sounding lead, and it therefore must lie above the point which is assumed to be the "bottom." The bottom-sediment specimen was taken as nearly as possible at one foot above this "bottom." It frequently varied from this point, of course, but presumably was as often below as above it. It can scarcely be doubted that the slip-bottle was actually in contact with the bottom when many of the specimens were taken, yet not a single observation shows any abnormal amount of sediment. Again: A stratum of material moving with such a velocity as to become a potent factor in transportation must necessarily be in a state of suspension, and if so, it must go where the water in which it is suspended goes. That the water is constantly rising from the bottom is beyond question; and therefore all rapidly-moving sediment must come within the scope of sediment observations.

The latter half of May was a period of appreciable wave action at Labarre, where the area was least and the velocity greatest. If the supposition of a rapidly-moving bottom stratum be adopted, the formation of waves can be explained in no other way than that this stratum contributes a portion of its material, no matter how small, to build them. But the amount contributed should be greater as the velocity is less, and therefore the wave action at this period should be greater at the other bases than at Labarre. On the contrary, there is little at Cambronne and none at Diamond.

The cases of well-determined movement of waves show almost universally that the progress of the wave is accompanied by a flattening of the front slope. It is possible that the observed change of position is only incident to the demolition of the wave.

A movement down stream of the profile as a whole is conspicuous at Labarre, but is of rare occurrence at the other bases. At the first named it is most noticeable when

local action is slight, and mainly occurs during a fill. It is not sufficient in amount to give it any importance.

It seems probable that sand waves are forms which freshly deposited sediment tends to assume under the action of a current of sufficient velocity. The dimensions reached by any wave depend upon the velocity and upon the rate ofdeposition. With high velocities the waves reach such size as to react upon the water and form eddies under the crests, which, by throwing into suspension all material pushed over the crest, stop the further growth of the wave. The wave retains its position until some change in velocity disturbs or displaces the eddy, when its rapid destruction, either partial or total, follows, after which a new wave is formed under the new conditions. Waves in any degree approaching the typical form reach large size only under the conditions stated, which conditions are unfavorable to the progressive motion of the same wave. Such motion rarely takes place except during the obliteration of the wave, when a part of the material scoured from it is deposited immediately below, thus flattening the front slope and carrying the crest down stream. After the wave has, under this action, entirely lost its original form, the whole profile may gradually move down stream, indicating a tendency to scour or rising and fill on descending grades. The circumstances under which such action is developed are not distinguished by the observations. It can only be said that it principally occurred at Labarre base where the section was widest and shallowest. The effects of all such motion are relatively inconsiderable.

The observations here discussed indicate that the material forming the waves is brought to the spot in suspension; that when the wave disappears the material goes away in suspension; and that fully 99 per cent. of the annual discharge of solid materials will be detected by the usual observations for sediment in suspension.

4. *Changes of channel capacity.*—As indicative of any general tendency on the part of the river to enlarge or contract its channel to accommodate its varying discharge, we naturally turn to the study of the datum areas of the cross-sections. The discharge section which was sounded more frequently than the others is treated by itself. For the rest, the three sections taken at the same time and place are combined into a mean section for that time and place. The mean sections are derived by taking twenty equidistant depths from each of the individual profiles, and taking the mean of the three depths at corresponding points for the depth of the mean section at a similar point. With the mean distance between ordinates the mean section in constructed. All the mean sections up to the end of April are derived from the elaborately sounded cross-sections. After that date they depend upon sections plotted from the longitudinal lines, and are, therefore, less reliable, being determined from about ten soundings only.

Comparing the curves of datum areas with the gauge curve, the first glance reveals a lack of concordance, which further study only confirms.

On the discharge section the maximum datum area occurs on January 16, at a stage of 10.25 feet, reached by a rapid rise from low water. The minimum, 20,000 square feet less than the former, occurs on June 19, at a stage of 7.5 feet, during a slight swell at the foot of the decline after the principal rise of the year. On August 9, at a stage of 4 feet, falling, another large area is observed, being but 6,000 square feet less than the maximum. From this date to the close of the operations (excepting, perhaps, the last day's work) a semblance of agreement between the curves is observable.

As to the sequence of the changes in datum area, we find the first rise of the year accompanied at first by a scour, followed by a fill of nearly equal amount. The middle of the succeeding decline finds an area about midway between these two. Now follows a persistent decrease of datum area, or fill on the bottom, continuing entirely through the long and very high rise of March, April, and May, and through a part of the succeeding decline. After this a slight swell and a small rise, which keep the river at about a mean stage, are accompanied by a series of fills and scours, the latter in excess, until low stage is reached, after which, as before observed, there is a trace of agreement, the scours corresponding to rising and the fills to falling river.

The above indications, which are those of a single section only, are in the main confirmed by the mean sections at the same locality; the only exception worth noting being that a slight scour, indicated in the discharge section at the end of March, is increased in the mean of the Labarre sections to an equality with the maximum of the year. It may also be remarked that it is possible to draw a curve corresponding closely with the gauge curve and passing through the points representing the areas of these mean sections.

The variations of the mean of the sections at Cambronne and Diamond bases differ radically from those described at Labarre; and, moreover, from the beginning of the observations to the period of highest water, they directly contradict each other.

A general tendency to scour is observable at Diamond, and the reverse at Cambronne, the latter being considerably the greater.

The former has but one marked exception, being a decided fill between January 21 and 26, coincident with which is the only pronounced scour which occurs at Cambronne during the period considered.

From the middle of May to the close of the work the indications of the cross-sections, for the reasons before stated, must be accepted with caution. They are given, however, for whatever value they may have. The mean of the Labarre sections (see Plate V, Fig. 1) exhibits great and apparently irregular variations. The same may be said of the Diamond sections (Fig. 2); and, moreover, the principal variations of the latter coincide in time and direction with those of the former. The Cambronne sections (Fig. 3), on the contrary (having recovered between April 28 and May 17 all the area previously lost by filling), remain comparatively constant. The Diamond and Cambronne sections had at the close of the work essentially the same area as at the beginning. The Labarre sections were considerably less.

All of these sections show the same trace of conformity to the gauge curve during the low water of August and September, which was noticed in the discharge sections.

Passing from the consideration of the abstract to that of the concrete areas, and determining the locus and scope of the changes noticed, by comparison of profiles, the absence at mean and high stages of any general action is strongly foreshadowed. The profiles of the discharge sections have been carefully compared, and also those of the mean sections at the three bases, during the first period. The cross-sections derived from the longitudinals are not sufficiently exact to be of use here.

The comparison of the profiles of the discharge section reveals a very consistent relation between the stage of the water and the *form* of the section. The normal shape of the section at low water is as shown by the full line in the profile of September 13, Plate VI.

In the deepest part of this section, where the thread of the low-water current is found, there is very little change at high water. But as the river rises there is a secondary channel developed on the other side, and a middle ground is formed between the two, as shown by the full line in profile of May 21.

The float observations show a corresponding change in the distribution of mid-depth velocities; a second maximum or thalweg being developed in the position of the secondary channel mentioned.

Several of the velocity curves, with corresponding sections, are plotted on Plate V. It is thought that they establish the fact that there is a tendency in the section to assume a form corresponding to the distribution of velocities.

The most violent and anomalous changes in the datum area of the discharge section are found to be invariably accompanied by change of form; while those during which the normal shape of the section is preserved show, in comparison with the gauge readings, a most significant consistency. The latter are grouped in the following table:

Discharge sections—similar forms.

Date.	Gauge.	Area.	Change.	
			Gauge.	Area.
December 17, 1879	2.5	132,700	.....	.....
January 3, 1880	7.3	135,500	+4.8	+2,800
January 16, 1880	10.2	141,000	+7.7	+8,300
February 13, 1880	10.5	138,500	+8.0	+5,800
August 9, 1880	4.2	136,000	+1.7	+3,300
August 16, 1880	2.6	132,200	+0.1	− 500
August 20, 1880	2.0	129,800	−0.5	−2,900
August 24, 1880	1.6	129,300	−0.9	−3,400
August 27, 1880	1.8	127,800	−0.7	−4,900
September 3, 1880	1.3	128,300	−1.2	−4,400
September 13, 1880	2.4	129,500	−0.1	−3,200
September 18, 1880	2.4	131,300	−0.1	−1,400
September 21, 1880	2.5	132,000	±0.0	− 700
September 30, 1880	1.5	131,300	−1.0	−1,400

Mean sections—Labarre.

December 6, 1879	1.6	135,800	.....	.....
December 26, 1879	6.0	135,290	+4.4	− 510
January 9, 1880	9.0	138,000	+7.4	+2,200
January 25, 1880	11.2	140,000	+9.6	+4,200
February 9, 1880	11.5	142,500	+9.9	+6,700

The fourth and fifth columns show the change in gauge reading and area, respectively, from the first observation (December 17). It will be noticed that, with one

exception, any gauge reading greater than the first is accompanied by an area greater than the first, and *vice versa*. The exception is on August 16, when the difference of gauge reading is only one-tenth, and the small difference of area (500 square feet) which corresponds to it rather strengthens the conclusion than otherwise. It will also be noticed that when, after an interval of nine months, with a high and low water intervening, the gauge returns to its first reading, the area differs only by 700 square feet from its first value, its changes meanwhile having been twenty times that amount, or over 10 per cent. of the entire section.

The mean sections at Labarre, which present the normal form, are introduced into the table. With the exception of that taken on December 6, the first of the series, the same relation prevails. Conditions precedent to the beginning of the work might indicate the cause of this exception; but we have nothing but the gauge reading, which gives no clew. It may be noted that this was the first day's work at this section, and the third of the season; and if any inaccuracy was introduced on account of inexperience, it must have resulted in the increase of the area, since every error, except a blunder in reading the line, which would probably be detected in plotting, has the effect of making the sounding too large. The areas near the close of the work are, for the reason already given, not sufficiently reliable to be introduced into this comparison.

As before stated, the variations of the Cambronne and Diamond sections are entirely contradictory. During the first part of the work, the Diamond sections show a tendency to scour, with an occasional fill, while the Cambronne sections seem inclined to fill, with occasional very slight tendencies to scour, which scarcely amount to more than a cessation of the filling. During the latter part of the season, the conditions are reversed at both places. The changes at these sections are both relatively and absolutely smaller than those at Labarre. They are never great enough to change the typical form of the section; but, in addition to their contradiction of each other, a study of the comparative profiles of the mean sections affords a strong presumption that they are not the result of an effort of the river to enlarge or contract its channelway by reason of increased or decreased flow, but that they are due to local causes. The profiles show no case where a general scour or fill extends uninterruptedly over any great portion of the bed. The lines frequently cross and recross each other, showing scour in some parts, and fill in others, the change of area being determined by the predominance of one or the other. The most important changes at both sections, however, are entirely consistent with what, from the few observations at hand, as well as from general information, may be assumed to have been the distribution of velocities at the varying stages of water. For instance, at Diamond base (Plate VII) the pronounced fill occurring between the surveys of January 13 and January 23 is entirely on the bluff side of the section, and is accompanied by a scour less in amount on the other side. This action occurs at mean stage, at which time the current has a tendency, as shown by the mean stage transverse velocity curve at this base, to leave the bend and draw across the point. The fill being in the eddy, was, of course, purely local. On the contrary, the maximum value of this section, occurring on April 12, at about the highest stage of water, is seen to be due to an unusual scour on the bluff side, accompanied by a fill in other parts of the section. By reference to the transverse velocity curves it will be seen that at high water the thread of the current again approaches the bend with greatly increased force. It crowds the eddy into smaller limits, and doubtlessly increases its violence, and slackwater is found under the point. At Cambronne the changes consist mainly in, first, the gradual formation of a lump on the shallow side; second, its sudden removal at the period of maximum velocity and discharge, accompanied by a nearly equal fill nearer the middle of the section; and third, the removal, at the beginning of the decline, of this last fill, thus restoring the section to its original form and nearly its original dimensions. For the rest of the season the changes are trifling, The second and third conditions noted are consistent with the mean and high stage velocity curves at that section.

If, instead of comparing the curves of datum areas at the three sections separately with the gauge curve, they be compared with each other, a condition in which contradictions may become reasonable, most of the inconsistencies disappear. The variations of the Diamond sections correspond very closely in time and direction with those at Labarre, while in all their important changes the Cambronne sections are opposed to the Diamond.

A sufficient cause, which explains and reconciles all these changes, is readily discernible; and, though local in character, it is probably repeated at so many points in the river's course that its effect is general. This cause is the shifting of the current at varying stages.

On Plate I, Fig. 2, are shown what appear to be the paths of the strongest current at low, mean, and high stages. A change from one to another of these positions will be accompanied by a scour in that portion of each section corresponding to the new position of the maximum velocity, with probably a fill in the part which it has left. The fill is less certain than the scour, as the latter is accomplished by the increase of

velocity alone, while to cause a deposit not only must the flow be checked, but the material to be deposited must be present in the water. Should the current, instead of shifting bodily, merely divide, the phenomenon, equally certain and obscure, of a heavy deposit between the two channels will occur, even though the central velocity should constantly and regularly increase. Such a case is presented at Labarre base. The above hypothesis accounts for all the important changes of area observed.

The general dimensions of the channel in this portion of the river vary but little, if at all, from year to year. A comparison of the present sections with the corresponding ones of 1851, and with the Coast Survey map of 1875–76, shows no changes greater than those which occurred during these observations. That a marked change in the channel capacity takes place on the first rise, at about mean stage, the results here presented leave but little doubt. It is, moreover, from the nature of the change, probable that it recurs each year under similar conditions. In such case, in order that the channel capacity remain practically the same, an equal and opposite change must occur during each river cycle. The discharge observations show that this second change did not take place previous to the cessation of work, though it was doubtless in progress, as the form of the Labarre sections shows that the obstruction was no longer there, and the low-water slope profile gives a very clear indication that it was still active a short distance above.

This second change must have occurred between October 1 and the lowest water. It must consist of a scour in the deepest part of the controlling section, and its cause must be the persistent action of the comparatively uniform and sluggish low-water current. It can, therefore, scarcely take place suddenly, but is, more probably, very gradual. If complete when the water reaches the lowest level, it must then allow a discharge equal to that resulting from the other branch of the discharge curve for the same reading. These considerations give the form of the lower connection of the two branches of the curve, as shown in Fig. 1, Plate II. That such is the real action of the stream seems the more probable when it is remembered that it is precisely what occurs, on a much larger scale, at every bar on the river.

CONCLUSIONS.

Certain general propositions seem fairly derivable from the foregoing facts and inferences, some of which are of local interest only, while others may find a wider application.

In the portion of river under consideration, the effort of the stream and the form of its bed are in comparative equilibrium. The variations from day to day are relatively small, and during the river cycle are compensatory.

Of these variations, those which appreciably affect the discharging capacity of the channel occur at two principal epochs. The first, which causes a marked diminution in capacity, takes place on the rise from low water, at a point somewhat above mean stage, and its immediate cause is a change from the low to the high water course of the stream. The capacity thus lost is gradually recovered during the low-water period. The first effect of the approaching flood is to impede its own discharge, and the impediment outlasts the flood. In the river's present condition, an increase of the discharge at or above mean stage would hasten and intensify the obstacle; an increase at or below mean stage would delay or prevent its removal.

So long as the thalweg remains in its low-water position, the rise and fall of the river are accompanied, respectively, by a scour and fill on the bottom, small in amount but definite. Could this condition be maintained, the high stage would slightly increase, instead of materially diminishing, the capacity of the channel, and the passage of a given flood volume would be effected with a few inches less height than at present.

The fixation of the thalweg cannot be accomplished by reduction of width alone. A width of 2,500 feet at Labarre is great enough to permit a pernicious shifting of the current. Contraction is essential to the degree which will cause the water to flow parallel to the banks. Beyond this the fixation of the thalweg, upon which depend the development and maintenance of the full channel capacity, can only be secured by means of the curves given the regulated channel.

TABLE No. 1.—*Discharge and sediment observations at Carrollton, La.*

Date.	Gauge.				Dimensions of cross-section of discharge.												Scour or fill.		Slope per 1,000 feet.		Velocity per second.				Discharge per second.		
	Reading.		Rise or fall in preceding 24 hours.		Area.				Depth.						Width.						Mean.		Maximum mid-depth.		Water.		Sediment.
					Water.		Below datum.		Mean.		Mean datum.		Maximum.														
1879.	*Ft.*	*M.*	*Ft.*	*M.*	*Sq. ft.*	*Sq. m.*	*Sq. ft.*	*Sq. m.*	*Ft.*	*M.*	*Ft.*	*M.*	*Ft.*	*M.*	*Ft.*	*M.*	*Sq. ft.*	*Sq. m.*	*Ft.*	*Mm*	*Ft.*	*M.*	*Ft.*	*M.*	*Cu. ft.*	*Steres.*	*Kilos.*
Dec. 17	2.52	0.768	+0.30	+0.091	138,900	12,903.9	132,839	12,340.8	57.5	17.52	56.5	17.22	82.0	25.0	2,415	736.0	.....	.....	.....	....	3.20	.975	4.31	1.313	444,396	12,582.7	.....
19	....	....	.....	.....	.....	.....	.....	.....	....	....	..	....	...	....	....	....	.....	.....	.....	...	....	....	..	.....	.....	.....	10,482.5
30	....	....	.....	.....	.....	.....	.....	.....	....	....	..	....	....	....	....	....	.....	.....	.....	....	....	....	....	.....	.....	.....	23,213.0
1880.																											
Jan. 3	7.46	2.273	+0.30	+0.091	153,495	14,260.0	135,412	12,579.9	62.7	19.11	57.6	17.55	85.6	26.1	2,451	747.0	+2,573	+239.0	.....	....	4.27	1.301	6.94	2.115	654,941	18,545.4	.....
16	10.20	3.109	+0.10	+0.030	166,662	15,483.1	141,379	13,134.2	65.6	19.99	60.2	18.35	87.3	26.6	2,541	774.5	+5,967	+554.3	.....	....	5.13	1.563	5.98	1.822	854,978	24,209.7	.....
21	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0142	4.33	.....	.....	.....	.....	.....	.....	.....
26	11.36	3.462	+0.05	+0.015	162,603	15,106.0	134,419	12,487.6	63.4	19.32	57.2	17.43	89.7	27.3	2,565	781.8	−6,960	−646.6	.....	....	5.08	1.548	5.66	1.725	827,106	23,420.4	.....
28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0127	3.87	.....	.....	.....	.....	.....	.....	.....
Feb. 13	10.49	3.197	−0.30	−0.091	164,655	15,296.6	138,629	12,878.6	64.2	19.56	59.0	17.98	91.0	27.7	2,565	781.8	+4,210	+391.1	.....	....	4.54	1.383	5.49	1.673	749,006	21,208.9	.....
14	.....	....	.....	.....	.....	.....	.....	.....	..	.....	..	....	....	....	....	....	.....	.....	.....	...	....	....	....	.....	.....	.....	13,760.0
17	....	....	.....	.....	.....	.....	.....	.....	...	.	....	.....	.....	.....	.	.....	.....	.....	0.0137	4.17	....	....	....	.....	.....	.....	.....
Mar. 5	11.80	3.597	0.00	0.000	163,350	15,175.4	134,287	12,475.3	64.6	19.69	57.1	17.40	89.7	27.3	2,530	771.1	−4,342	403.4	.....	....	5.04	1.536	6.34	1.932	823,731	23,324.7	.....
18	12.70	3.870	+0.20	+0.061	164,925	15,321.7	132,896	12,346.1	62.6	19.08	56.5	17.22	92.0	28.0	2,636	803.4	−1,391	−129.3	.....	...	5.24	1.597	6.71	2.045	863,013	24,437.2	.....
19	....	....	.....	.....	.....	.....	.....	.....	....	....	....	.....	....	....	....	....	.....	.....	.....	...	....	....	....	.....	.....	.....	27,272.7
23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0165	5.03	.....	.....	.....	.....	.....	.....	.....
Apr. 1	13.25	4.038	0.00	0.000	167,126	15,526.2	133,710	12,421.7	63.1	19.23	56.9	17.34	92.7	28.2	2,647	806.8	+814	+75.6	.....	...	5.90	1.798	7.57	2.307	986,875	27,944.4	.....
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	19,723.5
30	.....	..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....
May 4	.....	....	.....	.....	.....	.....	.....	.....	..	...	....	..	....	....	...	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	17,521.9
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0157	4.78	.....	.....	.....	.....	.....	.....	.....
21	12.55	3.825	−0.20	−0.061	156,330	14,523.3	124,566	11,572.2	58.7	17.89	53.0	16.15	95.0	28.9	2,665	812.3	−2,434	−226.2	.....	....	5.33	1.624	6.67	2.033	843,897	23,895.7	10,568.3
22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	..	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....
24	....	.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0136	4.14	.....	.....	.....	.....	.....	.....	.....
June 1	9.51	2.898	−0.40	−0.122	147,690	13,720.5	124,020	11,521.5	57.2	17.43	52.8	16.09	92.0	28.0	2,582	787.0	−546	−50.7	.....	....	4.46	1.359	4.97	1.514	658,818	18,655.1	.....
2	..	....	.....	.....	.....	..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	7,976.9
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0139	4.23	.....	.....	.....	.....	.....	.....	.....
11	.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	7,641.1
12	7.63	2.325	+0.05	+0.015	143,440	13,325.7	125,075	11,619.6	59.3	18.07	53.2	16.21	91.0	27.7	2,417	736.6	+1,055	+98.0	.....	....	4.05	1.234	4.65	1.417	580,884	16,448.3	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0112	3.41	.....	.....	.....	.....	.....	.....	.....
16	7.62	2.321	+0.05	+0.015	141,484	13,144.0	123,143	11,440.1	58.5	17.83	52.4	15.97	90.0	27.4	2,417	736.6	−1,932	−179.5	.....	....	3.91	1.191	4.48	1.365	552,755	15,651.7	.....
19	7.53	2.294	+0.05	+0.015	139,970	13,003.3	121,830	11,318.1	57.7	17.58	51.8	15.78	89.0	27.1	2,423	738.5	−1,313	−122.0	.....	....	3.73	1.136	4.52	1.377	521,744	14,773.6	8,196.5
24	6.86	2.090	−0.25	−0.076	143,190	13,302.5	126,733	11,773.6	59.6	18.16	53.9	16.42	90.0	27.4	2,401	731.8	+4,903	+455.5	.....	....	3.58	1.090	4.40	1.341	512,051	14,499.2	9,222.9
25	.....	....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0112	3.41	.....	.....	.....	.....	.....	.....	.....
29	5.86	1.786	0.00	0.000	140,850	13,085.0	126,891	11,788.3	59.1	18.01	54.0	16.46	90.0	27.4	2,381	725.7	+158	+14.6	.....	....	3.32	1.011	4.16	1.267	467,074	13,225.7	.....
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	8,296.7
July 2	5.86	1.786	+0.10	+0.030	140,670	13,068.3	126,671	11,767.8	58.8	17.92	53.9	16.42	88.0	26.8	2,392	729.0	−220	−20.5	.....	...	3.52	1.072	4.20	1.280	494,550	14,003.6	9,243.6
3	.....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0105	3.20	....	.....	.....	.....	.....	.....	.....

	8	6.93	2.112	0.00	0.000	143,235	13,306.6	126,451	11,747.4	59.1	18.01	53.8	16.39	87.0	26.5	2,422	738.2	— 220	— 20.5	.....	....	3.83	1.167	4.76	1.450	548,500	15,531.2	11,384.9
	16	8.40	2.560	+0.20	+0.061	148,680	13,812.4	128,646	11,951.2	60.8	18.53	54.7	16.67	88.0	26.8	2,445	745.2	+2,195	+204.0	.....	....	4.21	1.283	5.41	1.649	625,487	17,711.4	.....
	17	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	.....	....	....	....	....	....	.....	.....	.....	17,330.3
	24	8.60	2.621	+0.15	+0.045	148,680	13,812.4	127,569	11,851.2	60.8	18.53	54.3	16.55	88.0	26.8	2,445	745.2	—1,077	—100.0	.....	....	4.39	1.337	5.47	1.667	654,337	18,528.3	19,012.4
	26	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	0.0143	4.36	....	.....	....	.....	.....	.....	.....	.....
	31	7.57	2.307	+0.45	+0.137	151,290	14,055.1	133,258	12,379.7	62.5	19.05	56.7	17.28	90 0	27.4	2,438	743.0	+5,689	+528.4	.....	....	3.89	1.185	5.52	1.682	558,020	15,803.1	17,608.1
Aug.	5	5.72	1.743	+0.70	+0.213	143,770	13,356.3	130,345	12,109.2	60.7	18.50	55.5	16.91	86.0	26.2	2,369	722.0	—2,913	—270.6	.....	....	3.38	1.029	4.32	1.316	485,978	13,760.9	12,331.9
	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0097	2.95	...	.....	.....	.....	.....	.....	.....
	9	4.12	1.255	+0.45	+0.137	145,690	13,532.7	136,041	12,638.3	57.6	17.55	51.9	17.64	86.0	26.2	2,359	718.9	+5,696	+529.2	.....	....	2.95	0.899	3.86	1.176	429,720	12,167.9	.....
	10	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	.....	.....	.....	.....	11,975.9
	16	2.65	0.807	—0.25	—0.076	138,370	12,854.7	132,174	12,279.1	56.2	17.13	56.2	17.13	86.0	26.2	2,350	716.2	—3,867	—359.2	.....	....	2.59	0.789	3.36	1.023	358,735	10,158.0	8,107.4
	17	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	0.0053	1.67	..	.....	..	.....	.....	.....	.....	.....
	20	1.98	0.603	—0.05	—0.015	134,415	12,487.3	129,792	12,057.8	55.4	16.88	55.2	16.82	81 0	24 7	2,344	714.4	—2,382	—221.3	.....	....	2.33	0.710	3.13	0.953	312,684	8,853.9	6,641.4
	24	1.60	0.488	0.00	0.000	133,420	12,394.8	129,367	12,018.3	55.3	16.85	55.1	16.79	81.0	24.7	2,341	713.5	— 425	— 39.5	.....	....	2.37	0.722	3.26	0.993	316,136	8,951.0	5,336.1
	25	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	0.0065	1.98	....	.....	....	.....	.....	.....	.....	.....
	27	1.80	0.549	0.00	0.000	132,030	12,265.7	127,829	11,875.3	54.6	16.64	54.4	16.58	81.0	24.7	2,342	713.8	—1,538	—142.8	.....	....	2.17	0.661	2.87	0.874	287,177	8,131.7	3,968.8
Sept.	3	1.26	0.384	+0.10	+0.030	131,220	12,190.3	128,267	11,916.1	54.7	16.67	54.6	16.64	81.0	24.7	2,346	715.0	+ 438	+ 40.7	.....	....	1.71	0.521	2.18	0.663	225,044	6,372.3	1,223.8
	4	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	0.0087	2.65	....	.....	.....	.....	.....	.....	.....	.....
	13	2.32	0.707	+0.05	+0.015	134,730	12,516.5	129,306	12,012.6	55.0	16.76	55.0	16.76	83.0	25.3	2,351	716.5	+1,039	+ 96.5	.....	....	2.38	0.724	3.04	0.926	319,683	9,052.2	3,132.6
	18	2.44	0.744	—0.05	—0.015	136,960	12,723.7	131,238	12,192.1	55.5	16.91	55.8	17.00	83.0	25.3	2,365	720.8	+1,932	+179.5	.....	....	2.42	0.737	3.02	0.920	331,059	9,374.2	3,206.6
	21	2.46	0.749	—0.20	—0.061	137,700	12,792.4	131,939	12,257.2	55.9	17.03	56.1	17.10	83.0	25.3	2,358	718.6	+ 701	+ 65.1	.....	....	2.60	0.732	3.37	1.026	357,748	10,129.9	4,681.1
	30	1.33	0.405	—0.05	—0.015	134,325	12,478.9	131,218	12,190.2	55.9	17.03	55.8	17.00	82.0	25.0	2,347	715.3	— 721	— 66.9	.....	....	1.95	0.594	2.58	0.785	261,399	7,401.7	2,389.2
Oct.	1	....	....	.....	.....	.....	.....	.....	.....	....	....	....	....	....	....	.....	.....	.....	.....	0.0119	3.62	....	.....	....	.....	.....	.....	.....	.....
	8	1.70	0.518	+0.30	+0.091	130,810	12,152.3	126,495	11,751.6	53.8	16.39	53.8	16.39	80.0	24.4	2,350	716.2	—4,723	+438.7	.....	....	1.97	0.600	3.08	0.938	257,579	7,293.5	1,648.5

TABLE No. 2.—*Average and total discharges at Carrollton, La.*

Date.	Average gauge for month in feet.	Average discharge per section in 1,000 cubic feet.	Total discharge for month in 100,000 cubic feet.
December, 1879	3.28	464	12,406,176
January, 1880	9.86	792	21,211,200
February, 1880	10.56	747	18,727,200
March, 1880	12.61	883	23,647,680
April, 1880	13.48	951	24,662,880
May, 1880	12.87	907	24,308,640
June, 1880	7.51	556	14,407,200
July, 1880	7.65	569	15,236,640
August, 1880	3.31	372	9,961,920
September, 1880	1.91	294	7,624,800
October, 1880	1.05	220	5 883,840
November, 1880	1.19	234	6,073,920
Total	.....	.....	184,152,096

Average stage for year, 7.1 feet.
Average discharge for year, 582 thousand cubic feet per second.

TABLE No. 3.—*Observed inclination of water surface.*

Date.	Gauge.	Inclination in feet per mile.																							
		Station 1.		Station 2.		Station 3.		Station 4.		Station 5.		Station 6.		Station 7.		Station 8.		Station 9.		Station 10.		Station 11.		Station 12.		
		−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	
Jan. 19, 1880	10.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.109	.180	.....	.203	.....	High stage.
Jan. 28, 1880	11.50	.003	.....	.014	.....	.024	.....	.....	.004	.039	.....	.004	.....	.....	.008	.. .	.003	.001	.. .	.001	.....	.085	.....	.205	.....	
Feb. 17, 1880	9.10	.010	....	.012	.....	.049	.....	.....	.022	.042	.....	.026	.....	.045	.....	.009	.....	.....	.002	.....	.023	.151	.....	.182	.....	
Mar. 23, 1880	13.25	.019	.....	.014	... .	.072	.....	.....	.....	.....	.001	.070	.....	.....	.036	.....	.006	.....	.001	.....	.112	.188	.....	.260	....	
May 6, 1880	13.20	....	.017	.011	.....	.051	.....	.042	.....	.043	.....	.046	.....	.....	.067	.010	.....	.....	.001	.....	.086	.167	.....	.247	.....	
May 24, 1880	12.10	...	.027	.012	.....	.086	.....	.019	....	.037	.....	.052	.....	.....	.020	.037	.....	...	.034	.....	.126	.114	.....	.235	....	
June 3, 1880	9.00	.068	.	.006	.....	.070	.....	.....	.087	.054	.....	.103	.....	.....	.062	.056	.....	.023	.....	.....	.098	.074	.....	.187	.....	
July 26, 1880	8.70	.....	.009	.049	.....	.056	.....	.....	.021	.031	.....	.051	.....	.....	.072	.111	....	.....	.045	.....	.117	.133	.....	.237	.....	
Means	.....	.005	....	.019	....	.062	.....	.....	.012	.035	.....	.050	.....	.....	.031	.031	.....	.....	.008	.....	.084	.137	.....	.219	.....	
June 14, 1880	7.70	.008	.....	.....	.013	.087	....	.....	.065	.034	.....	.106	.....	.022	.....	.....	.070	.006	.....	.....	.036	.078	.....	.159	.....	Mean stage.
June 25, 1880	6.60	.135	....	....	.102	.050	.....	.051	....	.023	.....	.047	.....	.....	.053	.169	.....	.....	.121	.....	.153	.070	.....	.100	.....	
July 3, 1880	6.00	.061	....	.021	.....	.071	.....	.....	.072	.012	.....	.052	.....	.....	.064	.088	.....	.....	.03-	.001	.....	.0 3	.....	.152	.....	
Aug. 6, 1880	5.40	.036	....	.002	.....	.040	.....	.....	.021	.033	.....	.050	.....	.....	.113	.083	.....	.035	.....	.....	.061	.053	.....	.140	.....	
Means	.....	.060	....	.....	.050	.062	.. .	. . .	.027	.025	....	.064	....	.....	.052	.068	.....	.. .	.029	.....	.062	.053	.....	.138	.....	
Aug. 17, 1880	2.70	....	.001	.017	. .	.062	.....	.....	.014	.015	.....	.060	.....	.....	.139	.104	.....	.....	.057	.015	.....	.059	.....	.034	.....	Low stage.
Aug. 25, 1880	1.60	.....	.048	.....	.004	.166	.....	.....	.057	.025	.....	.054	.....	.....	.114	.105	.....	.....	.024	.....	.016	.056	.....	.040	.....	
Sept. 4, 1880	1.30	.....	.032	.....	....	.242	.....	.....	.058	....	.010	.052	.....	.....	.007	....	.042	.....	.060	.120	.....	.008	.....	.032	.....	
Oct. 1, 1880	1.20	....	.065	.....	.033	.351	.....	.....	.053	.034	.....	.041	.....	.....	.170	.096	.....	.....	.074	.104	.....	.007	.....	.100	....	
Means	.....	.....	.036	.....	.007	.205	.....	.....	.047	.017	.....	.052	.....	.....	.107	.066	.....	.....	.054	.056	.....	.032	.....	.051	.....	

APPENDIX F.

RESULTS OF GAUGING OPERATIONS ON THE UPPER MISSISSIPPI RIVER, FROM OCTOBER, 1880, TO OCTOBER, 1881.

OFFICE OF MISSISSIPPI RIVER COMMISSION,
Saint Louis, September 15, 1882.

MAJOR: I have the honor to submit herewith the final tabulated results of observations at Prescott, Winona, Clayton, Hannibal, Grafton, and Saint Louis from October, 1880, to October, 1881. In measuring velocities on this work the method of rod floats was adopted as a standard.

At Prescott, Winona, Clayton, and Hannibal the method of using the rods was the following:

A permanent anchorage was made by placing a series of rock anchors across the river, about 100 feet above the discharge section. To each anchor was attached a piece of No. 12 wire long enough to reach to the discharge section. A wire was then carried across the river, one end being made fast on each bank, and was fastened to the lower end of each anchor wire, the adjustment of lengths being so made that the points of junction fell on the discharge section and at about equal intervals. These points marked the stations where observations were to be taken. The system when not in use was allowed to lie on the bottom.

Across the stern of a large skiff an outrigger, 20 feet long, 5 inches wide, and 2 inches thick, was firmly fastened. This outrigger was graduated to feet, the graduations being conspicuously marked. From its extremities two wires, supported at intervals by floats, trailed down stream a distance of about 100 feet, and at their lower ends was fastened a second graduated strip, supported on three buoys. On the upstream face of the lower strip was fastened a ribbon of copper. In front of this ribbon, supported at each end on wooden bridges, a copper wire was tightly stretched. The distance between wire and ribbon was made just sufficient to prevent their touching when the wire vibrated under the action of wind or waves. It was generally about one-quarter of an inch. The ribbon was connected with one of the connecting wires, and the wire with the other. At the upper boat the ends of the connecting wires were connected with a battery and bell. At the middle of the lower strip was fastened a small skiff in which was a boatman. The entire apparatus being in position at one shore, the end of the cross-wire was picked up and placed over a pulley in the bow of the upper skiff, which was then worked out on the wire until the junction with the first anchor wire was reached, when it was made fast and observations began.

The boatmen in the lower skiff kept the staffs in bow and stern of the upper skift in line, thus causing the system to revolve, if at all, as a unit about the bow of the upper skiff in which a compass was placed. The reading of the compass, and the known position of the fixed point, gave at any instant the position of every point of the system, the important ones being the graduations on the strips. These precautions were found in practice to be excessive. The upper strip was about a foot above the surface of the water, while the lower one was but 6 inches. The rods were loaded so as to float about 9 inches out of water, so that they cleared the upper strip, but struck the lower one. They were put out at the bow of the upper boat, and the time noted when they passed under the first strip, as well as the nearest graduation. When they neared the lower strip they first struck the wire, which was forced back against the strip, thus closing the circuit, and ringing the bell in the upper boat, which marked the completion of the run. The boatman in the lower boat noted and called the division at which the float struck the lower strip, and then recovered the float. Six floats were run as described at each station. The times were measured with stop watches, beating fifths of seconds.

By the use of the apparatus above described, the lengths and positions of the float paths were known without observations from shore, and more accurately than they could have been determined in that way.

Many of the details were more fully elaborated, and at two of the places mentioned the zeal and ingenuity of the chiefs of party gave the results more accuracy than that proposed above. At Prescott no inspection was made during the season, but the results seem entirely satisfactory.

At Grafton and Saint Louis the difficulty of maintaining an anchorage necessitated the use of free rods located from shore. The locations were made in the usual manner.

Owing to the difficulty of handling the long rods required, the assistant at Grafton substituted mid-depth floats during the high-water stage.

At Grafton about twenty-two floats were run in determining a discharge. At Saint

Louis the number was usually ten. The latter number is too small, and goes far to explain the great disparity of individual results.

During the time that the ice was safe, velocities were measured with the current meter, the Ellis meter with the mercury contact being used. The meter was lowered through holes in the ice, and velocities were taken at mid-depth at different depths in the same vertical and by integration.

At Prescott and Winona the integrations were valueless on account of anchor ice, and at the former place the vertical curves could not be obtained. At Hannibal no vertical curves were taken.

While the river was filled with floating ice several approximate discharges were taken, the velocities being deduced from the time of passage of ice cakes past a base line. The sections could not be measured and the locations of the cakes were guessed at. The agreement of these results with the rest is therefore surprising. They are marked I C in the tabulation; R indicates rods, M meter, and F double floats.

The cross sections, when the permanent anchorage was used, are, from the method of obtaining them, unquestionably the most accurate of their size that have ever been taken in work of this character. When the plant could not be used the sections were determined from soundings carefully located from the shore, and are of no greater accuracy than that usually reached in such work.

Part of these notes were reduced, and the reductions checked in the field. Such work was revised in the office. Otherwise a duplicate office reduction was made. The Saint Louis observations were reduced in the field, but imperfectly, and an entire recomputation in the office was found necessary.

Mean velocities for any position were deduced from the observed rod velocities by the following formula (Francis):

$$V' = V\,[1 - 0.116\,(\sqrt{D} - 0.1)]$$ in which

V = observed rod velocity,

V' = mean velocity in the vertical,

$$D = \left(\frac{\text{depth of water minus immersion of rod.}}{\text{depth of water.}}\right)$$

Francis deduced this formula from observations in which the value of D was small, or where the rods could be run very near the bottom, the channel being an artificial and rectangular one. Such conditions not being obtainable in natural channels, the limits of applicability of the formula were experimentally tested by comparing rods of different immersions with mid-depth floats and meters. The formula was found to give good results with an immersion of only one-third the depth.

From the mean velocities and measured cross-sections, the discharge was computed by the method of partial areas.

At Prescott and Saint Louis the work of reduction was much complicated by the unfavorable sections used. This was, at Saint Louis, the result of hasty choice, made without sufficient examination; at Prescott the section was the best obtainable. The methods of reduction for these stations are fully explained in a preface to the tabulation.

In the observations made through the ice, the unusual conditions introduced necessitated a special and very careful treatment of the results. In designing the work, the usually accepted theories of the relative velocities at different depths could not be premised, since it was foreseen that the friction against the under surface of the ice would retard the upper filaments, but to what extent was entirely problematical. The influence of an up-stream wind was thought to be somewhat analagous, and as this is said by a high authority not to affect the flow at mid-depth, that point was assumed for observations at a single depth.

The integrations, or results obtained by lowering the meter uniformly from the surface to bottom, and drawing it up again in the same way, were designed to give the mean velocity as a check on the mid-depth observation. As an additional precaution, the observations at different depths in the same vertical were ordered. These, when plotted, give the position of mean velocity either graphically or analytically. When the results were all in they were analyzed as follows:

1st. Except when integrations could not be taken as above mentioned, each observation gave a direct comparison between mid-depth and integration velocities.

2d. Whenever vertical curves were taken they were accompanied by mid-depth and integration measurements, and each such set of results gave a direct comparison of mid-depth and integration velocities with mean velocity. Mean coefficients for the reduction of mid-depth and integration velocities to mean velocities were obtained, and the mean of the two determinations of mean velocity was used in computing the discharge. When the observations at any station were not complete enough to give both coefficients, the missing one was deduced from the nearest station, by assuming that the ratios between the known coefficient at the two stations was true for the other. In the following tabulation the values so determined are designated by an asterisk. At Saint Louis none of the coefficients were sufficiently determinate from the observations, and those of Grafton were adopted.

TABLE.

Station.	Ratio of mid-depth to integration velocities.			Ratio of mid-depth to mean velocities.			Ratio of integration and mean velocities.
	Mean value of coefficient.	Number of observations.	Range of individual results.	Mean value of coefficients.	Number of observations.	Range of individual results.	
Grafton, Ill	0.9431	151	0.2641	0.8893	120	0.2014	0.9430
Hannibal, Mo	0.9477	264	0.2609	*0.8915			*0.9407
Clayton, Iowa	0.9472	33	0.1330	0.9286	33	0.0820	0.9804
Winona, Minn	0.9468			0.8964	204	0.2099	*0.9467
Prescott, Wis				*0.9014			

The reliability and accuracy of meter work must depend on the meter itself. The cross-section can be taken through the ice with perhaps more accuracy than at any other time.

The reliability of the meter will depend, 1st, upon the certainty with which the registration corresponds with the revolution, and, 2d, upon the constancy of its rate.

The first condition was obtained by the form of the contact apparatus used, which, by its construction, made it impossible, without breakage of some of the parts, for the wheel to revolve without making and breaking the circuit, or for the circuit to be made or broken without the revolution of the wheel. The contact was made by a platinum wire dipping in mercury, which gives the lowest and therefore the least variable resistance. This contact, by dispensing with the necessity of any pressure adjustment, also contributed to constancy of rate. That the second condition was practically realized, no further evidence is thought necessary than that afforded by the table of ratings, appended.

At the Saint Louis station the meter was not brought into as successful use as at other points. For this reason, meter results at that station must be accepted with caution.

The foregoing is not intended as a report on this work, but is designed to supply certain information which, in connection with the tabulation, will enable a discussion to be made. The detail computation sheets and original field notes are available, should further data be desired.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary Mississippi River Commission.

Maj. CHARLES R. SUTER,
Acting Chairman of Committee on Surveys and Examinations.

METER RATINGS.

[Equation $y=ax+b$, in which y=velocity in feet per second, and x=number of revolutions per minute.]

Locality.	Date.	Meter.	Number of observations.	Registrations per revolution.	*a*.	*b*.	Authority.	Range of velocities.	Where taken.	Remarks.
								Feet.		
Saint Charles, Mo	Aug. —, 1879	Ellis No. 10	.....	2	0 061500	0. 092000	.....	.....	.....	$y=ax+b\pm0.019$.
Do	Aug. —, 1879	Ellis No. 8	.....	1	0. 058900	0. 204040	.....	.....	.....	$y=ax+b\pm0.014$.
Do	Oct. —, 1879	Ellis No. 8	.....	1	0. 059842	0. 091000	S. H. Younge	0. 6—5. 5	In a pond	
Clayton, Iowa	Dec. 5, 1880	Fllis No. 6	5	1	0. 062190	0. 127820	W. G. Price	1. 3—2. 9	....do	
Do	Dec. 12-13, '80	Ellis No. 6	19	1	0. 063570	0. 102780	....do	0. 3—3. 5	....do	
Do	Jan. 3, 1881	Ellis No. 6	10	1	0. 061880	0. 140540	... do	1. 4—1. 7	....do	
Do	Jan. 24, 1881	Ellis No. 6	12	1	0. 061930	0. 131510	....do	0. 7—3. 9	....do	
Do	Mar. 3, 1881	Ellis No. 6	16	1	0. 061530	0. 143420	....do	0. 7—3. 0	... do	
Do	Mar. 30, 1881	Ellis No. 6	9	1	0. 062280	0. 161750	do	1. 0—2. 7	....do	
Grafton, Ill	Jan. 3, 1881	Ellis No. 3	26	1	0. 062144	0. 139066	J. H. Davis	0. 7—7. 9	....do	
Do	Jan. 10, 1881	Ellis No. 3	30	1	0. 064323	0. 148163	... do	1. 0—7. 6	....do	
Do	Jan. 18, 1881	Ellis No. 3	21	2	0. 062649	0. 118665	... do	0. 7—3. 8	....do	
Do	Jan. 22, 1881	Ellis No. 3	31	2	0. 063030	0. 071931	....do	0. 6—2. 7	....do	
Do	Jan. 29, 1881	Ellis No. 3	23	2	0. 064699	0. 029263	....do	0. 9—3. 7	....do	
Hannibal, Mo	Jan. 22, 1881	Ellis No. (?)	24	1	0. 068101	0. 066670	H. P. Ritter	1. 0—5. 2	In the river	
Prescott, Wis	.....	Ellis No. (?)	9	1	0. 069054	0. 098207	F. A. Yaeger	0. 7—1. 6	In a pond	
Do	.....	Ellis No. (?)	12	1	0. 062677	0. 121777	....do	0. 7—1. 8	....do	
Saint Louis, Mo	May 28, 1881	Ellis No. 10	.....	.....	0. 062217	0. 140000	H. F. Palfrey	.....	Reservoir	
Do	Jan. 22, 1881	Ellis No. 10	.....	.....	0. 062500	0. 170000	....do	.....	River	

CURRENT AND SEDIMENT OBSERVATIONS.

The river sections at Winona, Clayton, Hannibal and Grafton are unobstructed by bars or islands, and hence the reduction of the observations at these stations does not require special treatment.

The section at Prescott is complicated by the presence of a slough, which at certain stages carries off large quantities of water, and at others contains a large area of stagnant water, or is dry.

The Saint Louis section is rendered similar to the one at Prescott by the presence of a bar, which becomes submerged at a stage of about 40′. The emergence of the bar has the effect of changing the cross-section from a simple form to that of one consisting of an unobstructed river and a slough.

The observations at these two stations, therefore, required special treatment, when the cross-section assumed its complex form, and in both it was found necessary to compute velocity and water area for the main river and slough separately.

With the exception of this special treatment, the detail of computation is identical with that pursued at the other stations, which in general follows the method employed in the reduction of observations at Fulton, Tenn., and Carrollton, La., during the season of 1879–'80.

In the subjoined tables the foot unit is used. Velocity is given in feet per second, and discharge in cubic feet per second.

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.

Date.	Locality.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Method.
1880.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Cu. ft. per sec.*	*Sq. feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	
Nov. 9	(Sec. 3)...	3.6	.....	8,181.8	1.606	13,142.0	.....	.....	.....	.....	R.
12	....do	4.0	.....	8,604.8	1.694	14,581.6	.....	.....	.....	.....	R.
19	... do.....	1.9	1,230	6,159.5	1.379	8,597.8	.....	.....	.....	.....	R.
Dec. 14	....do.....	178.0	1,230	6,338.9	1.244	7,882.5	37,664	11.5	.....	.....	M.
16	... do.....	177.9	1,230	6,309.7	1.171	7,385.8	37,758	11.6	.....	94	M.
21	....do.....	177.8	1,230	5,979.8	1.221	7,298.8	37,551	11.5	207	.....	M.
22	....do.....	177.8	1,230	6,102.0	1.188	7,252.0	37,671	11.5	.....	120	M.
23	....do.....	177.9	1,230	6,216.3	1.214	7,549.0	37,662	11.5	9	.....	M.
24	....do.....	177.9	1,230	6,175.5	1.185	7,318.8	37,621	11.5	41	.....	M.
31	....do.....	177.9	1,235	6,069.8	1.077	6,534.6	37,518	11.5	103	.....	M.
1881.											
Jan. 1	.. do.....	177.8	1,235	5,945.0	1.108	6,589.9	37,519	11.5	.....	1	M.
3	....do.....	177.7	1,235	5,897.0	1.093	6,446.2	37,594	11.5	....	75	M.
4	....do.....	177.7	1,235	5,862.0	1.123	6,378.7	37,559	11.5	35	.....	M.
5	....do.....	177.8	1,235	5,947.2	1.094	6,506.4	37,521	11.5	38	.....	M.
6	.. do.....	177.7	1,235	5,882.0	1.013	5,959.7	37,579	11.5	.....	58	M.
12	....do.....	177.7	1,235	5,841.2	1.105	6,452.6	37,538	11.5	41	.....	M.
13	....do.....	177.8	1,235	5,661.5	1.000	5,660.7	37,235	11.4	303	.....	M.
14	....do.....	177.8	1,235	5,759.5	1.235	7,115.5	37,333	11.4	.....	98	M.
15	....do.....	177.8	1,235	5,801.8	1.283	7,445.6	37,375	11.4	.....	42	M.
17	....do.....	177.7	1,235	5,812.2	1.162	6,752.5	37,508	11.5	.....	133	M.
18	....do.....	177.7	1,235	5,859.2	1.085	6,356.4	37,555	11.5	....	47	M.
19	....do.....	177.7	1,235	5,832.2	1.217	7,100.2	37,528	11.5	27	.....	M.
20	....do.....	177.7	1,235	5,887.0	1.209	7,118.2	37,583	11.5	.....	55	M.
21	....do.....	177.7	1,235	5,907.5	1.093	6.454.6	37,603	11.5	.....	20	M.
22	....do.....	177.7	1,235	5,857.5	0.989	5,790.9	37,553	11.5	50	.....	M.
24	....do.....	177.7	1,235	5,882.0	1.045	6,148.4	37,576	11.5	.....	25	M.
25	....do.....	177.8	1,235	6,241.2	1.067	6,657.1	37,812	11.6	.....	236	M.
26	....do.....	177.8	1,235	6,051.5	1.101	6,664.7	37,622	11.5	190	.....	M.
27	....do.....	177.8	1,235	6,071.2	1.127	6,843.9	37,642	11.5	.....	20	M.
28	....do.....	177.8	1,235	6,055.0	1.142	6,730.4	37,626	11.5	16	.....	M.
29	....do.....	177.8	1,235	6,052.5	1.100	6.658.8	37,623	11.5	3	.....	M.
31	....do.....	177.8	1,235	6,265.0	1.085	6,797.4	37,836	11.6	.....	213	M.
Feb. 1	... do.....	177.8	1,235	6,272.5	1.094	6,860.4	37,843	11.6	.....	7	M.
3	(Sec. 1)...	177.7	625	5,121.6	0.688	3,525.1	.....	.....	.....	.....	M.
4	....do.....	177.7	625	4,981.8	0.759	3,778.8	.....	.....	.....	.....	M.
5	....do.....	177.7	625	4,981.8	0.727	3,623.1	.....	.....	.....	.....	M.
7	....do.....	177.7	625	4,981.8	0.693	3,452.6	.....	.....	.....	.....	M.
8	....do.....	177 7	625	5,046.8	0.714	3.604.0	.....	.....	.....	.....	M.
9	....do.....	177.6	625	5,106.0	0.724	3,698.8	.....	.....	.....	.....	M.
10	....do.....	177.6	625	5,146.0	0.718	3,694.9	.....	.....	.....	.....	M.
11	....do.....	177.6	625	5,121.8	0.717	3,670.4	.....	.....	.....	.....	M.
12	....do.....	177.6	625	5,015.6	0.709	3,554.9	.....	.....	.....	.....	M.
14	....do.....	177.6	625	5,056.6	0.676	3.418.4	.....	.....	.....	.....	M.
15	... do.....	177.6	625	5,184.1	0.690	3,578.1	.....	.....	.....	.....	M.
16	....do.....	177.7	625	5,241.4	0.709	3,715.7	.....	.....	.....	.....	M.
17	....do.....	177.9	625	5,306.4	0.719	3,815.9	.....	.....	.....	.....	M

CURRENT AND SEDIMENT ODSERVATIONS AT PRESCOTT, WIS.—Continued.

Date.	Locality.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Method.
1881.			*Feet.*	*Sq. feet.*	*Ft. per sec.*	*Cu. ft per sec.*	*Sq. feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	
Feb. 18	(Sec. 1) ...	177. 9	625	5, 306. 4	0. 732	3, 886. 3	.....	.....	.....	.....	M.
19	....do.....	178. 0	625	5, 331. 2	0. 687	3, 661. 1	.....	.....	.....	.....	M.
21	....do	178 0	625	4, 947. 6	0. 733	3, 626. 6	.....	.....	.....	.....	M.
22	....do.....	178. 0	625	4, 955. 1	0. 797	3, 950. 5	.....	.....	.....	.....	M.
23	....do.....	178. 0	625	4, 942. 6	0. 785	3, 882. 0	.....	.....	.....	.....	M.
24	....do	178. 0	625	4. 950. 1	0. 780	3, 862. 4	.....	.....	.....	.....	M.
25	....do.....	178. 0	625	4, 967. 6	0. 718	3, 566. 9	.....	.....	.....	.....	M.
26	.. do. ...	178. 0	625	4, 975. 1	0. 726	3, 613. 5	.....	.....	.....	.....	M.
Mar. 5	(Sec. 1*a*) ..	176. 9	518	3, 330. 5	1. 179	3, 925. 7	.....	.....	.....	.....	M.
7	....do.....	176. 9	518	3, 266. 4	1. 243	4, 059. 7	.....	.....	.....	.....	M.
8	....do.....	176. 9	518	3, 276. 4	1. 242	4, 070. 6	.....	.....	.....	.....	M.
9	....do.....	176. 9	518	3, 284. 8	1. 236	4, 058. 8	.....	.....	.....	.....	M.
10	....do.....	176. 9	518	3, 292. 3	1. 193	3, 928. 2	.....	.....	.....	.....	M.
11	....do.....	177. 0	518	3, 289. 8	1. 264	4, 159. 4	.....	.....	.....	.....	M.
12	....do	177. 0	518	3, 286. 3	1. 232	4, 049. 1	.....	.....	.....	.....	M.
14	....do.....	177. 0	518	3, 314. 8	1. 163	3, 855. 3	.....	.....	.....	.....	M.
15	....do.....	177. 3	538	3, 352. 8	1. 193	3, 999. 8	.....	.....	.....	.....	M.
16	....do.....	177. 3	538	3, 387. 8	1. 192	4, 037. 9	.....	.....	.....	.....	M.
17	....do.....	177. 5	538	3, 461. 8	1. 176	4, 071. 2	.....	.....	.....	.....	M.
17	(Sec. 3) ...	177. 0	.....	6, 253. 6	1. 143	7, 152. 0	38, 799	11. 9	.....	.....	M.
18	(Sec. 1*a*) ..	177. 5	538	3, 459. 6	1. 196	4, 137. 6	.....	.....	.....	.....	M.
18	(Sec. 3) ...	177. 0	.....	6, 284. 0	1. 108	6, 962. 3	38, 880	11. 9	.....	31	M.
19	(Sec. 1*a*) ..	177. 5	538	3, 467. 1	1. 213	4, 206. 6	.....	.....	.....	.....	M.
21	....do.....	177. 5	538	3, 452. 1	1. 227	4, 236. 4	.....	.....	.....	.....	M.
21	(Sec. 3) ...	177. 0	1, 228	6, 204. 7	1. 130	7, 009. 4	38, 750	11. 9	80	.....	M.
22	(Sec. 1*a*) ..	177. 5	538	3. 476. 8	1. 204	4, 185. 6	.....	.....	.....	.....	M.
23	.. do.....	177. 7	538	3, 511. 6	1. 196	4, 199. 2	.....	.....	.....	.....	M.
23	(Sec. 3) ...	177. 0	1, 228	6, 203. 4	1. 147	7, 113. 8	38, 749	11. 9	1	.....	M.
24	(Sec. 1*a*) ..	177. 7	538	3, 529. 1	1. 258	4, 439. 0	.....	.....	.....	.....	M.
24	(Sec. 3) ...	177. 2	1, 228	6, 431. 6	1. 264	8, 131. 1	38, 732	11. 9	17	.....	M.
25	(Sec. 1*a*) ..	177. 9	538	3, 569. 1	1. 235	4, 407. 1	.....	.....	.....	.....	M.
25	(Sec. 3) ...	177. 3	1, 228	6, 772. 9	1. 208	8, 483. 5	38, 975	11. 9	.....	243	M.
26	(Sec. 1*a*) ..	178. 3	538	3, 599. 8	1. 337	4, 812. 9	.....	.....	.....	.....	M.
26	(Sec. 3) ...	177. 4	1, 228	6, 782. 3	1. 263	8, 569. 3	38, 830	11. 9	145	.....	M.
28	....do.....	177. 6	1, 228	7, 164. 3	1. 340	9, 587. 9	38, 991	11. 9	.....	161	M.
29	....do.....	177. 6	1, 228	7, 183. 2	1. 384	9, 947. 6	38, 961	11. 9	30	.....	M.
30	... do.....	177. 7	1, 228	7, 233. 4	1. 500	10, 849. 3	38, 937	11. 9	24	.....	M.
Apr. 1	....do.....	177. 7	1, 228	7, 164. 7	1. 433	10, 271. 2	38, 841	11. 9	96	.....	M.
2	....do.....	177. 7	1, 228	7, 251. 2	1. 435	10, 405. 1	38, 879	11. 9	.....	38	M.
4	....do.....	177. 8	1, 228	7, 264. 6	1. 509	10, 962. 0	38, 819	11. 9	60	.....	M.
5	....do.....	177. 8	1, 228	7, 246. 6	1. 568	11, 361. 9	38, 801	11. 9	18	.....	M.

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.

Date.	Locality.	Gauge.	Main river.				Slough.			
			Water width.	Water area.	Mean velocity.	Discharge.	Water width.	Water area.	Mean velocity.	Discharge.
1881.			*Feet.*	*Sq. feet.*	*Ft. p. s.*	*Cu. ft. p. s.*	*Feet.*	*Sq. feet.*	*Ft. p. s.*	*Cu. ft. p. s.*
Apr. 19	(Sec. 3)	182. 9	1, 265	13, 209. 0	2. 25	29, 780. 8	2, 000	2, 000	0. 0	0. 0
20	..do	183. 7	1, 265	13, 761. 0	2. 38	32, 768. 7	2, 000	3, 450	0. 0	0. 0
21	..do	184. 4	1, 265	14, 818. 5	2. 54	37, 650. 6	2, 000	5, 060	0. 0	0. 0
22	..do	185. 0	1, 265	15, 419. 8	2. 54	39, 278. 4	2, 000	6, 350	0 0	0. 0
23	..do	185. 6	1, 265	16, 624. 8	2. 64	43, 901. 7	2, 000	7, 550	0. 0	0. 0
25	..do	186. 8	1, 265	18, 373. 3	2. 80	51, 396. 0	2, 000	9, 940	0. 13	1, 280. 0
26	..do	187. 6	.....	.....	.....	.....	.....	.....	.....	.....
27	..do	189. 4	.....	.....	.....	.....	.....	.....	.....	.....
28	..do	191. 4	.....	.....	.....	.....	.....	.....	.....	.....
29	..do	192. 4	.....	.....	.....	.....	.....	.....	.....	.....
30	..do	192. 9	.....	.....	.....	.....	.....	.....	.....	.....
May 2	..do	192. 4	.....	.....	.....	.....	.....	.....	.....	.....
3	..do	191. 7	.....	.....	.....	.....	.....	.....	.....	.....
6	..do	189. 7	1, 265	22, 290. 5	3. 03	67, 583. 8	2, 000	15, 717	0. 66	10, 373. 5
7	..do	189. 2	1, 265	21, 722. 2	2. 99	64, 930. 3	2, 000	14, 820	0. 68	10, 070. 0
9	..do	188. 4	1, 265	20, 462. 2	2. 91	59, 608. 4	2, 000	13, 200	0. 41	5, 500. 0
10	..do	188. 1	1, 265	19, 381. 2	2. 86	56, 039. 4	2, 000	12, 600	0. 38	4, 700. 0

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.—Continued.

Date.	Locality.	Gauge.	Main river.				Slough.			
			Water width.	Water area.	Mean velocity.	Discharge.	Water width.	Water area.	Mean velocity.	Discharge.
1881.			*Feet.*	*Sq. feet.*	*Ft. p. s.*	*Cu. ft. p. s.*	*Feet.*	*Sq. feet.*	*Ft. p. s.*	*Cu. ft. p. s.*
May 11	(Sec. 3)	187.9	1,265	19,208.0	2.76	53,045.8	2,000	12,017	0.32	3,845.6
12	..do	187.9	1,265	19.667.8	2.80	55,158.4	2,000	12,117	0.30	3,635.2
13	..do	187.8	1,265	19,293.2	2.80	54,128.7	2,000	11,857	0.29	3,438.5
14	..do	188.0	1,265	19,669.7	2.92	57,449.4	2,000	12,217	0.35	4,276.1
16	..do	188.4	1,265	20,100.0	2.91	58,652.2	2,000	13,117	0.40	5,247.0
17	..do	188.3	1,265	20.394.8	2.85	58,136.8	2,000	12,957	0.40	5,183.0
18	..do	188.2	1,265	19,839.8	2.84	56,474.0	2,000	12,817	0.40	5,127.0
19	..do	188.1	1,265	19,782.0	2.87	56,901.2	2,000	12,417	0.35	4,346.1
20	..do	187.9	1,265	19,155.5	2.83	54,352.6	2,000	12,057	0.33	3,979.0
21	..do	187.7	1,265	19,093.8	2.76	52,772.5	2,000	12,657	0.27	3,417.0
23	..do	187.2	1,265	18,486.2	2.69	49,765.2	2,000	10,717	0.20	2,143.0
24	..do	186.8	1,265	18,048.8	2.58	46,645.1	2,000	10,217	0.17	1,736.0
25	..do	186.5	1,265	17,549.0	2.51	44,097.0	2,000	9,517	0.07	666.0
26	..do	186.2	1,265	17,306.2	2.46	42,590.3	2,000	8,800	0.00	0.0
27	..do ...	186.0	1,265	16,719 0	2.44	40,810.2	2,000	8,280	0.00	0.0
28	..do	185.6	1,265	16,425.0	2.36	38,822.9	2,000	7,600	0.00	0.0
30	..do	185.0	1,265	15,976.5	2.34	36,774.4	2,000	6,350	0.00	0.0
31	..do	185.0	1,265	15,817.5	2.35	37,262.8	2,000	6,400	0.00	0.0
June 1	..do	185.4	1,265	16,199.2	2.34	37,936.8	2,000	7,150	0.00	0.0
2	..do	185.9	1,265	17,083.5	2.53	43,258.3	2,000	8,200	0.00	0.0
3	..do	186.1	1,265	17,213.5	2.51	43,326.6	2,000	8,550	0.00	0.0
4	..do	186.1	1,265	17,230.0	2.53	43,718.2	2,000	8,550	0.00	0.0
6	..do	186.6	1,265	17,498.2	2.51	43,006.9	2,000	9,517	0.07	666.0
7	..do ...	186.6	1,265	17,579.0	2.53	44,560.1	2,000	9,517	0.07	666.0
8	..do	186.5	1,265	17,433.8	2.48	43,358.5	2,000	9,237	0.04	369.0
10	..do	186.1	1,265	16,786.0	2.34	39,277.7	2,000	8,550	0.00	0.0
11	..do	185.8	1,265	16,400.0	2.37	38,924.8	2,000	7,950	0.00	0.0
13	..do	185.3	1,265	16,054.0	2.39	38,435.6	2,000	6,600	0.00	0.0
14	..do	185.3	1,265	15,830.2	2.39	37,946.7	2,000	6,780	0.00	0.0
16	..do	185.6	1,265	16,106.2	2.47	39,828.7	2,000	7,600	0.00	0.0
17	..do	185.8	1,265	16,355.2	2.49	40,786.3	2,000	7,950	0.00	0.0
18	..do	186.1	1,265	.....	.....	.....	.....	.....	.....	.....
20	..do	186.4	1,265	16,846.5	2.51	42,372.6	2,000	9,120	0.02	200.0
21	..do	186.4	1,265	16,821.5	2.52	42,499.7	2,000	9,120	0.02	200.0
23	..do	186.4	1,265	16,781.5	2.48	41,717.7	2,000	9,120	0.02	200.0
24	..do ...	186.4	1,265	16,738.5	2.50	41,946.0	2,000	9,120	0.02	200.0
25	..do	186.2	1,265	16,370.2	2.40	39,352.5	2,000	8,720	0.02	200.0
27	..do	185.7	1,265	15,989.0	2.42	38,742.5	2,000	7,800	0.02	200.0
28	..do	185.7	1,265	15,895.8	2.39	38,017.8	2,000	7,800	0.02	200.0
29	..do	185.9	1,265	16,210.2	2.47	40,092.6	2,000	8,100	0.02	200.0
30	..do ...	185.8	1,265	16,219.8	2.43	39,444.3	2,000	7,950	0.02	200.0
July 1	..do	185.4	1,265	15,983.0	2.35	37,775.6	2,000	7,150	0.02	200.0
2	..do ...	185.2	1,265	15,750.5	2.35	36,922.0	2,000	6,780	0.02	200.0
5	..do	185.2	1,265	15,213.7	2.33	35,524.7	2,000	6,780	0.02	200.0
6	..do	184.5	1,265	14,817.0	2.22	32,983.0	2,000	5,300	0.02	200.0
7	..do	184.2	1,265	14,415.0	2.28	32,881.3	2,000	4,700	0.02	290.0
8	..do ...	183.9	1,265	13,988.5	2.24	31,366.4	2,000	4,100	0.02	200.0
9	..do	183.5	1,265	13,509.5	2 14	28,911.1	2,000	3,300	0.02	200.0
11	..do ...	183.0	1,265	12,829.5	1.99	25,563.5	2,000	2,230	0.02	200.0
12	..do	182.7	1,265	12,449.0	2.10	26,211.4	2,000	1,600	0.02	200.0
13	..do	182.4	1,265	12,050.0	1.98	23,856.6	2,000	1,000	0.02	200.0
14	..do ...	182.4	1,265	12,140.0	1.94	23,539.2	2,000	1,000	0.02	200.0
15	..do	182.6	1,265	12,250.5	1.97	24,169.8	2,000	1,420	0.00	000.0
16	..do	182.8	1,265	12,502.0	2.08	26,012.6	2,000	1,800	0.00	000.0
18	..do	183.0	1,265	12,758.0	2.08	26,599.6	2,000	2,230	0.00	000.0
19	..do	183.0	1,265	12,843.0	2.06	26,565.4	2,000	2,230	0.00	000.0
21	..do	182.8	1,265	12,436.5	1.99	24,827.5	2,000	1.800	0.00	000.0
22	..do	182.5	1,265	12,320.5	2.01	24,853.0	2,000	1,250	0.00	000.0
22	(Sec. 1)	183.4	708	9,050.6	2.41	21,831.8	.....	.....	.....	.....
23	(Sec. 3)	182.3	1,265	11,859.0	2.01	23,920.0	2,000	800	0.00	000.0
25	..do	181.9	1,265	11,272.5	1.98	22,412.4	00	0	0.00	000.0
26	..do .	181.7	1,265	11,087.5	1.95	21,724.1	00	0	0.00	000.0
26	(Sec. 1)	182.4	680	7,688.0	2.21	17,026.4	00	0	0.00	000.0
27	(Sec. 3)	181.4	1,265	10,740.0	1.86	20,079.0	00	0	0.00	000.0
27	(Sec. 1)	182.2	678	7,588.3	2.17	16,483.4	00	0	0.00	000.0
28	(Sec. 3)	181.1	1,265	10,525.5	1.82	19,168.0	00	0	0.00	000.0
28	(Sec. 1)	182.0	671	7,469.5	2.23	16,454.9	00	0	0.00	000.0
29	(Sec. 3)	180.9	1,265	10,071.2	1.75	17,685.0	00	0	0.00	000.0
29	(Sec. 1)	181.2	675	7,482.5	2.10	15,636.9	00	0	0.00	000.0
30	(Sec. 3)	180.6	1,258	9,889.7	1.73	17,100.1	00	0	0.00	000.0
Aug. 1	..do	180.2	1,255	9,393.8	1.64	15,475.0	00	0	0.00	000.0
2	..do	180.0	1,255	9,008.8	1.73	15,614.0	00	0	0.00	000.0
2	(Sec. 1)	180.5	675	6,950.0	1.85	12,889.3	00	0	0.00	000.0
3	..do	180.4	675	6,899.8	1.73	11,983.3	00	0	0.00	000.0
4	(Sec 3)	179.3	1,250	8,845.5	1.71	15,140.5	00	0	0.00	000.0
4	(Sec. 1)	180.3	670	6,657.2	1.67	11,148.4	00	0	0.00	000.0

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.—Continued.

Date.	Total.						Slope per 1,000.	Sediment.					Method.
								Milligrams in 500 cubic centimeters.				Parts in 100,000.	
	Water area.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.		Surface.	Middle dpth.	Bottom.	Mean.		
1881.	*Sq. feet.*	*Cu. ft. p.s.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft.*							
Apr. 19	15,209.0	29,780.8	38,557	11.8	244	.....	.....	.....	.....	.....	.....	.....	R.
20	17,211.0	32,768.7	37,947	11.6	610	.....	.....	.....	.....	.....	.....	.....	R.
21	19,878.5	37,650.6	38,329	11.7	.....	382	.....	.....	.....	.....	.....	.....	R.
22	21,769.8	39,278.4	38,261	11.7	68	.....	.....	.....	.....	.....	.....	.....	R.
23	24,174 8	43,901.7	38,707	11.9	.....	446	.....	.....	.....	.....	.....	.....	R.
25	28,313.3	52,676.0	38,765	11.9	.....	58	.....	.....	.....	.....	.....	.....	R.
26	.....	.....	.....	.....	.....	.....	.....	113	148	200	152	31	
27	.....	.....	.....	.....	.....	.....	.....	175	322	345	291	56	
28	.....	.....	.....	.....	.....	.....	.....	155	124	174	144	30	
29	.....	.....	.....	.....	.....	.....	.....	68	126	127	112	21	
30	60,261.2	133,969.4	.....	.....	.....	.....	.....	72	.....	114	93	19	R.
May 2	.....	.....	.....	.....	.....	.....	.....	62	57	82	65	13	R.
3	.....	.....	.....	.....	.....	.....	.....	32	34	54	38	8	R.
6	38,007.5	77,956.8	38,991	11.9	.....	226	.....	.....	.....	.....	.....	.....	R.
7	35,542.2	75,000.0	38,158	11.9	833	.....	.....	.....	.....	.....	.....	.....	R.
9	33,662.2	65,108.4	39,053	12.0	.....	895	.....	.....	.....	.....	.....	.....	R.
10	31,981.2	60,739 4	38,188	11.7	865	.....	.....	.....	.....	.....	.....	.....	R.
11	31,225.0	56,891.4	38,248	11.7	.....	60	.....	.....	.....	.....	.....	.....	R.
12	31,784.8	58,793.6	38,808	11.9	.....	560	.....	.....	.....	.....	.....	.....	R.
13	31,150.2	57,567.2	38,434	11.8	374	.....	.....	.....	.....	.....	.....	.....	R.
14	31,886.7	61,725.5	38,420	11.8	14	.....	.....	.....	.....	.....	.....	.....	R.
16	33,217.0	63,899.2	38,444	11.8	.....	24	.....	.....	.....	.....	.....	.....	R.
17	33,351.8	63,319.8	38,906	11.9	.....	462	.....	.....	.....	.....	.....	.....	R.
18	32,656.8	61,601.0	38,537	11.8	369	.....	.....	.....	.....	.....	.....	.....	R.
19	32,199.0	61,247.3	38,732	11.9	.....	195	.....	.....	.....	.....	.....	.....	R.
20	31,212.5	58,331.6	38,072	11.7	660	.....	.....	.....	.....	.....	.....	.....	R.
21	31,750.8	56,189.5	39,263	12.0	.....	1,191	.....	.....	.....	.....	.....	.....	R.
23	29,203.2	51,908.2	38,347	11.7	916	.....	.....	.....	.....	.....	.....	.....	R.
24	28,265.8	48,381.1	38,716	11.9	.....	369	.....	.....	.....	.....	.....	.....	R.
25	27,066.0	44,766.0	38,496	11.8	220	.....	.....	.....	.....	.....	.....	.....	R.
26	26,106.2	42,590.3	38,516	11.8	.....	20	.....	.....	.....	.....	.....	.....	R.
27	24,999.0	40,810.2	38,062	11.7	454	.....	.....	.....	.....	.....	.....	.....	R.
28	24,025.0	38,822.9	38,394	11.8	.....	332	.....	.....	.....	.....	.....	.....	R.
30	22,326.5	36,774.4	38,654	11.8	.....	260	.....	.....	.....	.....	.....	.....	R.
31	22,217.5	37,262.8	38,545	11.8	109	.....	.....	.....	.....	.....	.....	.....	R.
June 1	23,349.2	37,936.8	38,371	11.8	174	.....	.....	.....	.....	.....	.....	.....	R.
2	25,283.5	43,258.3	38,673	11.8	.....	302	.....	.....	.....	.....	.....	.....	R.
3	25,763.5	43,326.6	38,500	11.8	173	.....	.....	.....	.....	.....	.....	.....	R.
4	25,780.0	43,718.2	38,517	11.8	.....	17	.....	.....	.....	.....	.....	.....	R.
6	27,015.2	43,672.9	38,121	11.7	396	.....	.....	.....	.....	.....	.....	.....	R.
7	27,096.0	45,226.1	38,202	11.7	.....	81	.....	.....	.....	.....	.....	.....	R.
8	26,670.8	43,727.5	38,101	11.7	101	.....	.....	.....	.....	.....	.....	.....	R.
10	25,336.0	39,277.7	38,072	11.7	29	.....	.....	.....	.....	.....	.....	.....	R.
11	24,350.0	38,924.8	38,065	11.7	7	.....	.....	.....	.....	.....	.....	.....	R.
13	22,654.2	38,435.0	38,001	11.6	64	.....	.....	.....	.....	.....	.....	.....	R.
14	22,610.2	37,946.7	37,957	11.6	44	.....	.....	.....	.....	.....	.....	.....	R.
16	23,706.2	39,828.7	38,074	11.7	.....	117	.....	.....	.....	.....	.....	.....	R.
17	24,305.2	40,786.3	38,020	11.6	54	.....	.....	.....	.....	.....	.....	.....	R.
18	.....	.....	.....	.....	.....	.....	.....	.....	37	41	38	8	R.
20	25,966.5	42,572.6	37,722	11.6	298	.....	.....	.....	.....	.....	.....	.....	R.
21	25,941.5	42,699.7	37,697	11.5	25	.....	0.050	.....	.....	.....	.....	.....	R.
23	25,901.5	41,917.7	37,657	11.5	40	.....	.....	.....	.....	.....	.....	.....	R.
24	25,858.5	42,146.0	37,614	11.5	43	.....	0.095	.....	.....	.....	.....	.....	R.
25	25,030.2	39,352.5	37,439	11.5	175	.....	0.070	18	43	54	40	8	R.
27	23,789.0	38,742.5	37,830	11.6	.....	391	0.068	.....	.....	.....	.....	.....	R.
28	23,695.8	38,017.8	37,737	11.6	93	.....	.....	.....	.....	.....	.....	.....	R.
29	24,310.2	40,092.6	37,699	11.5	38	.....	0.073	.....	.....	.....	.....	.....	R.
30	24,169 8	39,444.3	37,884	11.6	.....	185	0.075	.....	.....	.....	.....	.....	R.
July 1	23,133.0	37,775.6	38,153	11.7	.....	269	0.075	.....	.....	.....	.....	.....	R.
2	22,530.5	36,922.0	38,203	11.7	.....	50	.....	26	22	.....	23	5	R.
5	21,993.0	35,524.7	37,666	11.6	537	.....	.....	.....	.....	.....	.....	.....	R.
6	20,117.0	32,983.0	38,075	11.7	.....	409	0.070	.....	.....	.....	.....	.....	R.
7	19,115.0	32,881.3	38,052	11.7	23	.....	0.068	.....	.....	.....	.....	.....	R.
8	18,088.5	31,366.4	38,004	11.6	48	.....	0.072	.....	.....	.....	.....	.....	R.
9	16,809.5	28,911.1	38,031	11.6	.....	27	0.065	17	24	36	25	5	R.
11	15,059.5	25,563.5	37,913	11.6	118	.....	.....	.....	.....	.....	.....	.....	R.
12	14,049.0	26,211.4	37,882	11.6	31	.....	.....	.....	.....	.....	.....	.....	R.
13	13,050.0	23,856.7	37,862	11.6	20	.....	.....	.....	.....	.....	.....	.....	R.
14	13,140.0	23,539.2	37,952	11.6	.....	90	.....	.....	.....	.....	.....	.....	R.
15	13,670.5	24 169.8	37,829	11.6	123	.....	.....	.....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.—Continued.

Date.	Total.						Slope per 1,000.	Sediment.					Method.
								Milligrams in 500 cubic centimeters.				Parts in 1,000.	
	Water area.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.		Surface.	Middle dpth.	Bottom.	Mean.		
1881.	*Sq. feet.*	*Cu. ft. p. s.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft.*							
July 16	14, 302. 0	26, 012. 6	37, 808	11. 6	21	.....	.....	21	31	39	31	6	R.
18	14, 988. 0	26, 599. 6	37, 841	11. 6	.....	33	.....	.....	.....	.....	.....	.....	R.
19	15, 073. 0	26, 565. 4	37, 926	11. 6	..	85	0. 072	.....	.....	.....	.....	.....	R.
21	14, 236. 5	24, 827. 5	37, 742	11. 6	184	.....	.....	.....	.....	.....	.....	.....	R.
22	13, 570. 5	24, 853. 0	38, 055	11. 7	.....	313	.....	.....	.....	.....	.....	.....	R.
22	9, 050. 6	21, 831. 8	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
23	12, 659. 0	23, 920. 0	37, 797	11. 6	258	.....	.....	21	22	26	23	5	R.
25	11, 272. 5	22, 412. 4	37, 717	11. 6	80	.....	.....	.....	.....	.....	.....	.....	R.
26	11, 087. 5	21, 724. 1	37, 785	11. 6	.....	68	.....	.....	.....	.....	.....	.....	R.
26	7, 688. 0	17, 026. 4	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
27	10, 740. 0	20, 079. 0	37, 817	11. 6	.....	32	.....	.....	.....	.....	.....	.....	R.
27	7, 588. 3	16, 483. 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
28	10, 525. 5	19, 168. 0	37, 982	11. 6	.....	165	0. 062	.....	.....	.....	.....	.....	R.
28	7, 469. 5	16, 454. 9	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
29	10, 071. 2	17, 685 0	37, 782	11. 6	201	.....	.....	.....	.....	.....	.....	.....	R.
29	7, 432. 5	15, 636. 9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
30	9, 889. 7	17, 100. 1	37, 932	11. 6	.....	146	.....	24	33	43	33	7	R.
Aug. 1	9. 393. 8	15, 475. 0	37, 938	11. 6	.....	6	.....	.....	.....	.....	.....	.....	R.
2	9, 008. 8	15, 614. 0	37, 864	11. 6	74	.....	.....	.....	.....	.....	.....	.....	R.
2	6, 950. 0	12, 889. 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
3	6, 899. 8	11, 983. 3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.
4	8, 845. 5	15, 140. 5	37, 954	11. 6	.....	90	.....	.....	.....	.....	.....	.....	R.
4	6, 657. 2	11, 148. 4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.

Date.	Locality.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Method.
1881.		*Feet.*	*Feet.*	*Sq. ft.*	*Ft. per sec.*	*Cu. ft. per sec.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	
Aug. 5	(Sec. 3)...	179. 8	1, 250	8, 753. 8	1. 60	14, 070. 5	37, 862	11. 6	92	.....	R.
5	(Sec. 1)...	180. 2	670	6, 205 0	1. 74	10, 811. 9	.....	.....	.....	.....	R.
6	(Sec. 3)...	179. 8	1, 250	8, 697. 5	1. 71	14, 945. 8	37, 806	11. 6	56	.....	R.
9	....do	180. 5	1, 250	9, 390. 0	1. 85	17, 400. 6	37, 623	11. 5	183	.....	R.
10	... do.....	180. 5	1, 250	9, 595. 0	1. 70	16, 292. 0	37, 828	11. 6	.....	205	R.
10	(Sec. 1)...	180. 9	670	7, 107. 5	1. 55	11, 060. 6	.....	.....	.....	.....	R.
11	(Sec. 3)...	180. 4	1, 250	9, 285. 0	1. 73	16, 070. 6	37, 633	11. 5	195	.....	R.
12	....do	180. 3	1, 250	9, 385. 0	1. 77	16, 663. 0	37, 858	11. 6	.....	225	R.
12	(Sec. 1)...	180. 8	670	6, 808. 2	1. 60	10, 937. 0	.....	.....	.....	.....	R.
13	(Sec. 3)...	180. 2	1, 250	9, 060. 0	1. 73	15, 735. 0	37, 658	11. 5	200	.....	R.
15	... do.....	179. 6	1, 250	8, 430. 0	1. 48	12, 532. 2	37, 778	11. 6	.....	120	R.
15	(Sec. 1)...	180. 1	666	6, 635. 0	1. 28	8, 533. 1	.....	.....	.....	.....	R.
16	(Sec. 3)...	179. 5	1, 250	8, 271. 2	1. 57	13, 016. 2	37, 745	11. 6	33	.....	R.
16	(Sec. 1)...	180. 1	666	6. 727. 5	1. 33	9, 000. 8	.....	.....	.....	.....	R.
17	(Sec. 3)...	179. 6	1, 250	8, 290. 0	1. 58	13, 162. 5	37, 640	11. 5	105	.....	R.
17	(Sec. 1)...	180. 2	666	6, 725. 8	1. 39	9, 379. 7	....	.....	.....	.....	R.
18	(Sec. 3)...	179. 7	1, 250	8, 392. 5	1. 70	14, 315. 4	37, 617	11. 5	23	.....	R.
18	(Sec. 1)...	180. 4	666	6, 667. 4	1. 48	9, 898. 8	.....	.....	.....	.....	R.
19	(Sec. 3)...	179 8	1, 250	8, 555. 0	1. 71	14, 681. 1	37, 655	11. 5	.....	38	R.
19	(Sec. 1)...	180. 6	666	6, 981. 0	1. 54	10, 762. 3	....	.....	.....	.....	R.
20	(Sec. 3)...	180. 2	1, 250	8, 805. 0	1. 76	15, 563. 1	37, 405	11. 5	250	.....	R.

Date.	Locality.	Gauge.	Main river.				Slough.				Total.						Method.
			Water width.	Water area.	Mean velocity.	Discharge.	Water width.	Water area.	Mean velocity.	Discharge.	Water area.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	
1881.			*Feet.*	*Square feet.*	*Ft. pr. sec.*	*Cu. ft. pr. sec.*	*Feet.*	*Sq. feet.*	*Ft. pr. sec.*	*Cu. ft. pr. sec.*	*Sq. feet.*	*Cu. ft. pr. sec.*	*Sq. ft.*	*Feet.*	*Sq. ft.*	*Sq. ft*	
Aug. 22	(Sec. 3)	181.2	1,265	10,442.5	1.82	19,070.4	.....	.....	.....	.....	10,442.5	19,070.4	37,782	11.6	.....	377	R.
22	(Sec. 1)	181.9	676	7,977.1	1.66	13,312.2	.....	.....	.....	.....	7,977.1	13,312.2	.....	.....	.....	.....	R.
23	(Sec. 3)	181.6	1,265	10,895.0	1.95	21,334.7	.....	.....	.....	.....	10,895.0	21,334.7	37,729	11.6	53	.....	R.
23	(Sec. 1)	182.2	680	8,112.2	1.64	13,335.4	.....	.....	.....	.....	8,112.2	13,335.4	.....	.....	.....	.....	R.
24	(Sec. 3)	181.7	1,265	10,985.1	1.93	21,204.0	.....	.....	.....	.....	10,985.1	21,204.0	37,693	11.6	36	.....	R.
24	(Sec. 1)	182.2	680	8,118.2	1.59	12,931.5	.....	.....	.....	.....	8,118.2	12,931.5	.....	.....	.....	.....	R.
25	.. do....	182.2	680	7,958.2	1.57	12,496.9	.....	.....	.....	.....	7,958.2	12,496.9	.....	.....	.....	.....	R.
26	(Sec. 3)	181.7	1,265	11,003.0	1.92	21,154.8	.....	.....	.....	.....	11,003.0	21,154.8	37,711	11.6	.....	18	R.
27	.. do....	181.7	1,265	11,050.0	1.88	20,821.3	.....	.....	.....	.....	11,050.0	20,821.3	37,758	11.6	.....	47	R.
29	.. do....	182.8	1,265	12,525.0	2.08	26,103.6	2,000	1,800.0	.....	.....	14,325.0	26.103.6	37,833	11.6	.....	75	R.
29	(Sec. 1)	183.2	680	8,799.7	1.46	12,889.9	.....	.....	.....	.....	8,799.7	12,889.9	.....	.....	.....	.....	R.
30	(Sec. 3)	183.6	1,265	13,505.0	2.08	28,124.5	2,000	3,450,0	.....	.....	16,955.0	28,124.5	37,847	11.6	.....	14	R.
31	.. do....	183.8	1,265	13,847.5	2.08	28,876.7	2,000	3,850.0	.....	.....	17,697.5	28,876.7	37,936	11.6	.....	89	R.
31	(Sec. 1)	183.8	681	8,955.0	1.49	13,347.2	.....	.....	.....	.....	8,955.0	13,347.2	.....	.....	.....	.....	R.
Sept. 2	(Sec. 3)	183 6	1,260	13,582.5	2.09	28,360.4	2,000	3,450.0	.....	.....	17,032.5	28,360.4	37,928	11.6	12	....	R.
3	...do....	183.6	1,265	13,505.0	2.03	27,385.0	2,000	3,450.0	.....	.....	16,955.0	27,385.0	37,851	11.6	77	.....	R.
6	...do....	183.2	1,265	13,012.5	1.96	25,621.0	2,000	2,650.0	.....	.....	15,662.5	25,621.0	37,863	11.6	.....	12	R.
7	.. do....	183.0	1,265	12,890.0	1.96	25,320.4	2,000	2,230.0	.....	.....	15,120.0	25,320.4	37,974	11.6	.....	111	R.
8	.. do...	183.4	1,265	13,525.0	2.12	28,755.6	2,000	3,050.0	.....	.....	16,575.0	28,755.6	38,123	11.7	.....	149	R.
8	(Sec. 1)	183.6	681	8,951.2	1.91	17,114.8	.....	.....	.....	.....	8,951.2	17,114.8	.....	.....	.....	.....	R.
9	(Sec. 3)	184.3	1,265	14,1 5.2	2.15	30,461.8	2,000	4,900.0	.....	.....	19,035.2	30,461.8	37,645	11.5	478	.....	R.
12	.. do....	187.6	1,260	18,566.8	2.80	52,115.1	2,000	11,517.0	0.35	4,000.1	30.083.8	56,115.2	37,919	11.6	.....	274	R.
13	...do....	188.2	1,260	18,950.5	2.81	53,302.0	2,000	12,617.0	0.41	5,173.0	31,567.5	58,475.0	37,446	11.5	473	.....	R.
13	(Sec. 1)	188.9	800	12,636.2	2.50	31,619.9	2,000	8,000.0	0.50	4,000.0	20,636.2	35,619.9	.....	.....	.....	.....	R.
14	(Sec. 3)	188.5	1,265	19,649.2	2.82	55,554.5	2,000	13,377.5	0.50	6,688.2	33,026.7	62,242.7	37,925	11.6	.....	479	R.
14	(Sec. 1)	189.2	800	12,642.5	2.58	32,611.3	2,000	8,065.0	0.55	4,435.8	20,707.5	37,047.1	.....	.....	.....	.....	R.
16	(Sec. 3)	188.6	1,265	19,726.0	2.73	53,804.6	2,000	13,557.5	0.50	7,049.6	33,283.5	60,854.2	37,855	11.6	70	.....	R.
17	...do....	188.5	1,265	19,693.8	2.79	54,986.3	2,000	13,317.5	0.47	6,259.2	33,011.3	61,245.5	37,909	11.6	.....	54	R.
19	...do....	188.4	1,265	19,546.5	2.83	55,503.9	2,000	13,375.0	0.43	5,649.1	32,921.5	61.153.0	38,146	11.7	.....	237	R.
19	(Sec. 1)	189.3	800	12,238.8	2.50	30,640.0	2,000	8,120.0	0.60	4,872.0	20,358.8	35,512.0	.....	.....	.....	.....	R.
20	(Sec. 3)	188.3	1,265	19,512.0	2.72	53,060.8	2,000	12,917.0	0.40	5,167.0	32.429.0	58,227.8	37,980	11.6	166	.....	R.
20	(Sec. 1)	189.5	800	12,530.0	2.70	33,821.7	2,000	7,904.0	0.47	3,714.7	20,434.0	37,536.4	.....	.....	.....	.....	R.
21	(Sec. 3)	188.3	1,265	19,659.0	2.83	55,693.5	2,000	12,917.0	0.40	5,167.0	32,576.0	60,860.5	38,127	11.7	.....	147	R.
24	...do....	188.2	1,265	19,673.8	2.70	53,099.8	2,000	12,917.0	0.38	4,832.6	32,590.8	57,932.4	38,468	11.8	.....	341	R.
26	...do....	188.1	1,265	19,275.5	2.67	51,493.4	2,000	12,517.8	0.35	4,381.2	31,793.3	55,874.6	37,997	11.6	471	.....	R.
27	...do....	188.1	1,265	19,081.5	2.75	52,594.3	2,000	12,557.5	0.33	4,034.0	31,639.0	56,628.3	37,843	11.6	154	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT PRESCOTT, WIS.—Continued.

Date.	Locality.	Gauge.	Main river.				Slough.				Total.						Method.
			Water width.	Water area.	Mean velocity.	Discharge.	Water width.	Water area.	Mean velocity.	Discharge.	Water area.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	
1881.			*Feet.*	*Square feet.*	*Ft. pr. sec.*	*Cu. ft. pr. sec.*	*Feet.*	*Sq. feet.*	*Ft. pr. sec.*	*Cu. ft. pr. sec.*	*Sq. feet.*	*Cu. ft. pr. sec.*	*Sq. feet.*	*Feet.*	*Sq. ft.*	*Sq. ft.*	
Sept. 28	(Sec. 3)	188.0	1,265	18,923.0	2.66	50,304.9	2,000	12,217.5	0.30	3,665.2	31,140.5	53,970.1	37,671	11.5	172	.....	R.
30	...do....	187.9	1,265	18,890.8	2.66	50,359.2	2,000	10,995.8	0.32	3,543.1	29,886.6	53,802.3	36,744	11.3	927	.....	R.
Oct. 1	...do....	188.6	1,265	19,729.5	2.78	54,812.0	2,000	13,557.5	0.52	7,049.6	33,287.0	61,861.6	37,859	11.6		1,115	R.
3	...do....	190.1	1,265	21,670.0	3.19	69,034.8	2,000	16,317.5	0.73	11,830.2	37,987.5	80,875.0	37,662	11.5	197	.....	R.
4	...do....	190.3	1,265	21,980.5	3.22	70,909.9	2,000	16,917.5	0.80	13,534.0	38,898.0	84,443.9	37,919	11.6	.....	257	R.
7	...do....	190.2	1,265	21,965.5	3.01	66,231.8	2,000	16,617.5	0.77	12,795.5	38,583.0	79,027.3	37,930	11.6	11	.....	R.
8	...do....	190.0	1,265	21,560.5	3.18	68,618.7	2,000	16,317.5	0.72	11,748.6	37,878.0	80,367.3	37,878	11.6	52	.....	R.
10	...do....	189.6	1,265	21,072.5	2.87	60,443.9	2,000	15,577.5	0.64	9,969.6	36,650.0	70,413.5	37,956	11.6	.....	78	R.
12	...do....	189.5	1,265	20,876.5	2.93	61,196.4	2,000	15,257.5	0.62	9,596.5	36,134.0	70,792.9	37,766	11.6	190	.....	R.
13	...do....	189.4	1,265	20,741.0	2.81	58,288.3	2,000	15,117.5	0.60	9,070.5	35,858.5	67,358.8	37,817	11.6	.....	51	R.
14	...do....	189.4	1,265	20,745.5	2.98	61,808.6	2,000	15,117.5	0.60	9,070.5	35,863.0	70,879.1	37,822	11.6	.....	5	R.
17	...do....	189.5	1,265	20,942.0	3.10	64,896.8	2,000	15,317.1	0.63	9,649.7	36,259.1	74,546.5	37,892	11.6	.....	70	R.
18	...do....	189.5	1,265	20,823.5	3.13	65,139.2	2,000	15,317.1	0.63	9,649.7	36,140.6	74,788.9	37,774	11.6	118	.....	R.
20	.. do....	189.3	1,265	20,480.5	2.94	60,360.1	2,000	14,977.0	0.61	9,136.0	35,457.5	69,496.1	37,744	11.6	30	.....	R.
21	...do....	189.3	1,265	20,449.0	3.03	62,052.9	2,000	14,917.5	0.58	8,652.2	35,366.5	70,705.1	37,653	11.5	91	.....	R.
22	...do....	189.1	1,265	20,231.0	2.93	59,262.0	2,000	14,517.5	0.55	7,984.4	34,748.5	67,246.4	37,688	11.5	.....	35	R.
24	...do....	188.7	1,265	19,984.0	2.90	58,046.7	2,000	13,717.5	0.52	7,133.1	33,701.5	65,179,8	37,947	11.6	.....	259	R.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1880.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C.ft.pr. sec.*	*Square feet.*	*Feet.*	*Sq. feet*	*Sq. feet*							
Oct. 26	2.30 p. m.	435.9	1,476	9,130	2.320	21,186.4	24,690	13.5	.....	.....	.....	.....	.....	.....	.....	.....	R.
27	11.42 a. m.	435.9	1,443	9,290	2.116	20,659.1	24,850	13.6	.....	160	.....	.....	.....	.....	.....	.....	R.
30	2.35 p. m.	436.0	[Homer.]	9,300	2.302	21,412.1	[Homer sec	tions.]	.....	.....	.....	.....	.....	.....	.....	.....	R.
31	11.41 a. m.	436.0	1,395	8,840	2.228	19,696.1	24,252	13.3	598	.....	.....	.....	.....	.....	.....	.....	R.
Nov. 1	10.25 a. m.	435.9	1,401	9,280	2.374	22,038.9	24,840	13.6	.....	588	.....	.....	.....	.....	.....	.....	R.
2	11.45 a. m.	435.9	1,401	8,960	2.195	19,668.7	24,520	13.4	320	.....	.....	.....	.....	.....	.....	.....	R.
3	2.13 p. m.	435.9	1,475	9,470	1.967	18,632.6	25,030	13.7	.....	510	.....	.....	.....	.....	.....	.....	R.
4	10.52 a. m.	435.9	1,481	9,280	2.232	20,722.2	24,831	13.6	199	.....	.....	.....	.....	.....	.....	.....	R.
5	10 50 a. m.	435.9	1,477	9,620	2.882	27,730.0	25,171	13.8	.....	340	.....	.....	.....	.....	.....	.....	R.
6	2.41 p. m.	435.9	1,479	9,300	2.283	21,238.1	24,851	13.6	320	.....	.....	.....	.....	.....	.....	.....	R.
7	2.50 p. m.	435.7	1,475	9,280	1.921	17,827.6	25,127	13.8	.....	276	.....	.....	.....	.....	.....	.....	R.
8	3.20 p. m.	435.7	1,479	9,040	1.959	17,712.0	24,887	13.7	240	.....	.....	.....	.....	.....	.....	.....	R.
9	10.30 a. m.	435.7	1,474	9,450	2.036	19,243.6	25,297	13.9	.....	410	.....	.....	.....	.....	.....	.....	R.
12	9.20 a. m.	436.3	1,480	9,960	2.489	24,793.3	24,919	13.7	378	.....	.....	.....	.....	.....	.....	.....	R.
13	2.10 p. m.	436.1	1,488	9,820	2.448	24,042.3	25,075	13.7	.....	156	.....	.....	.....	.....	.....	.....	R.
14	10.10 a. m.	436.1	1,489	9,780	2.388	23,359.4	25,035	13.7	40	.....	.....	.....	.....	.....	.....	.....	R.
15	7.50 a. m.	436.0	1,487	9,370	2.376	22,270.4	24,773	13.6	262	.....	.....	.....	.....	.....	.....	.....	R.
Dec. 8	1.00 p. m.	434.6	1,433	8,270	1.064	8,797.6	24,110	13.2	663	.....	.....	.....	.....	.....	.....	.....	M.
9	12.30 p. m.	435.1	1,452	9,300	1.215	11,300.0	24,418	13.4	.....	308	.....	.....	.....	.....	.....	.....	M.
10	1.00 p. m.	435.6	1,472	9,860	1.348	13,287.2	24,393	13.4	25	.....	.....	.....	.....	.....	.....	.....	M.
11	10.15 a. m.	435.7	1,473	9,950	1.462	14,544.3	24,336	13.3	57	.....	.....	.....	.....	.....	.....	.....	M.
13	3.15 p. m.	435.9	1,477	10,080	1.571	15,827.1	24,172	13.2	164	.....	.....	.....	.....	.....	.....	.....	M.
14	2.15 p. m.	435.8	1,478	10,070	1.577	15,881.5	24,310	13.3	.....	138	.....	.....	.....	.....	.....	.....	M.
15	12.45 p. m.	435.8	1,477	9,950	1.571	15,627.7	24,190	13.3	120	.....	.....	.....	.....	.....	.....	.....	M.
16	12.15 p. m.	435.7	1,476	9,800	1.562	15,305.1	24,187	13.3	3	.....	.....	.....	.....	.....	.....	.....	M.
17	10.00 a. m.	435.5	1,472	9,640	1.564	15,080.4	24,321	13.3	.....	134	.....	.....	.....	.....	.....	.....	M.
18	9.15 a. m.	435.5	1,471	9,360	1.555	14,561.9	24,041	13.2	280	.....	.....	.....	.....	.....	.....	.....	M.
20	9.15 a. m.	435.4	1,472	9,100	1.534	13,960.3	23,928	13.1	113	.....	.....	.....	.....	.....	.....	.....	M.
21	2.50 p. m.	435.3	1,472	9,260	1.525	14,125.1	24,235	13.3	.....	307	.....	.....	.....	.....	.....	.....	M.
22	9.00 a. m.	435.2	1,472	8,920	1.527	13,622.0	24,052	13.2	193	.....	.....	.....	.....	.....	.....	.....	M.
23	10.00 a. m.	435.3	1,471	8,950	1.591	14,236.4	24,072	13.2	.....	30	.....	.....	.....	.....	.....	.....	M.
24	10.15 a. m.	435.2	1,471	8,950	1.544	13,817.2	24,219	13.3	.....	147	.....	.....	.....	.....	.....	.....	M.
25	9.15 a. m.	435.2	1.471	8,950	1.616	14,468.4	24,219	13.3	0	0	.....	.....	.....	.....	.....	.....	M.
27	1.00 p. m.	435.2	1,463	8,650	1.446	12,579.3	23,919	13.1	300	.....	.....	.....	.....	.....	.....	.....	M.
28	1.00 p. m.	434.2	1,414	7,250	1.178	8,545.0	23,956	13.2	.....	37	.....	.....	.....	.....	.....	.....	M.
29	1.00 p. m.	433.6	1,413	6,480	1.211	7,845.9	23,752	13.0	204	.....	.....	.....	.....	.....	.....	.....	M.
30	12.20 p. m.	433.7	1,420	7,030	1.378	9,692.4	24,019	13.2	.....	267	.....	.....	.....	.....	.....	.....	M.
31	10.20 a. m.	434.4	1,466	8,880	1.306	11,598.7	25,292	13.9	.....	1,273	.....	.....	.....	.....	.....	.....	M.

CURRENT AND SEDIMENT OBSERVATIONS AT WINONA, MINN.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet*	*Ft. per sec.*	*C. ft. pr. sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Jan. 1	11.30 a. m.	434.3	1,430	7,990	1.454	11,619.0	23,968	13.1	1,324	.....	.....	.....	.....	.....	.....	.....	M.
3	12.10 p. m.	434.8	1,434	8,460	1.490	12,608.9	23,722	13.0	246	.....	.....	.....	.....	.....	.....	.....	M.
4	10.00 a. m.	434.9	1,420	8,630	1.547	13,356.4	23,749	13.0	.....	27	.....	.....	.....	.....	.....	.....	M.
5	11.30 a m.	434.9	1,414	8,630	1.540	13,295.2	23,749	13.0	0	0	.....	.....	.....	.....	.....	.....	M.
6	10.15 a. m.	434.9	1,414	8,660	1.562	13,526.9	23,779	13.0	.....	30	.....	.....	.....	.....	.....	.....	M.
7	12.10 p. m.	435.0	1,414	8,740	1.556	13,603.8	23,718	13.0	61	.....	.....	.....	.....	.....	.....	.....	M.
8	10.15 a. m.	434.7	1,418	8,570	1.483	12,716.5	23,831	13.6	.....	113	.....	.....	.....	.....	.....	.....	M.
10	12.30 p. m.	434.7	1,418	8,370	1.495	12,513.1	23,631	13.5	200	.....	.....	.....	.....	.....	.....	.....	M.
11	10.20 a. m.	434.6	1,412	8,240	1.408	11,604.4	23,643	13.5	.....	12	.....	.....	.....	.....	.....	.....	M.
12	11.30 a. m.	434.7	1,412	8,380	1.451	12,148.7	23,642	13.5	1	.....	.....	.....	.....	.....	.....	.....	M.
13	11.45 a m.	434.7	1,412	8,330	1.467	12,222.4	23,592	13.5	50	.....	.....	.....	.....	.....	.....	.....	M.
14	11.45 a. m.	434.6	1,412	8,240	1.422	11,718.6	23,643	13.5	.....	51	.....	.....	.....	.....	.....	.....	M.
15	10.25 a. m.	434.5	1,412	8,080	1.387	11,212.6	23,624	13.5	19	.....	.....	.....	.....	.....	.....	.....	M.
17	12.00 m.	434.6	1,411	8,380	1.463	12,262.3	23,783	13.0	.....	159	.....	.....	.....	.....	.....	.....	M.
18	10.15 a. m.	434.6	1,408	8,250	1.511	12,468.1	23,653	13.0	130	.....	.....	.....	.....	.....	.....	.....	M.
19	11.20 a. m	434.5	1,408	8,190	1.428	11,697.2	23,734	13.0	.....	81	.....	.....	.....	.....	.....	.....	M.
20	10.00 a m.	434.5	1,408	7,940	1.439	11,426.0	23.484	12.9	250	.....	.....	.....	.....	.....	.....	.....	M.
21	11.25 a. m.	434.7	1,411	8,190	1.524	12,484.2	23,516	12 9	.....	32	.....	.....	.....	.....	.....	.....	M.
22	9.45 a. m.	434.7	1,419	8,420	1.486	12,515.2	23,746	13.0	.....	230	.....	.....	.....	.....	.....	.....	M.
24	11.10 a. m.	434.7	1,419	8,370	1.459	12,219.8	23,696	13.0	50	.....	.....	.....	.....	.....	.....	.....	M.
25	9.45 a. m.	434.6	1,419	8,320	1.445	12,025.0	23,788	13.0	.....	92	.....	.....	.....	.....	.....	.....	M.
26	12.15 p. m.	434.6	1,416	8,260	1.426	11,785.0	23,728	13.0	60	.....	.....	.....	.....	.....	.....	.....	M.
27	10.25 a. m.	434.4	1,417	8,020	1.356	10,879.4	23,771	13.0	.....	43	.....	.....	.....	.....	.....	.....	M.
28	10.20 a. m.	434.3	1,403	7,790	1.363	10,621.1	23,682	13.0	89	.....	.....	.....	.....	.....	.....	.....	M.
29	10.10 a. m.	434.5	1,409	8,130	1.429	11,624.5	23,740	13.0	.....	58	.....	.....	.....	.....	.....	.....	M.
31	11.35 a. m.	434.7	1,423	8,630	1.465	12,646.1	23,955	13.1	.....	215	.....	.....	.....	.....	.....	.....	M.
Feb. 1	12.15 p. m.	434.7	1,423	8,480	1.445	12,258.5	23,805	13.0	150	.....	.....	.....	.....	.....	.....	.....	M.
2	10.20 a. m.	434.7	1,423	8,480	1.472	12,487.2	23,805	13.0	0	0	.....	.....	.....	.....	.....	.....	M.
3	12.15 p. m.	434.7	1,423	8,450	1.418	11,986 0	23,775	13.0	30	.....	.....	.....	.....	.....	.....	.....	M.
4	12.25 p. m.	434.7	1,423	8,370	1.442	12,084.9	23,695	13.0	80	.....	.....	22	33	49	34	7	M.
5	12.50 p. m.	434.7	1,423	8,460	1.382	11,690.6	23,785	13.0	.....	90	.....	.....	.....	.....	.....	.....	M.
7	11.45 a m.	434.7	1,422	8,400	1.360	11,429.4	23,725	13.0	60	.....	.....	.....	.....	.....	.....	.....	M.
8	10.10 a. m.	434 8	1,423	8,500	1.406	11,958.6	23,683	13.0	42	.....	.....	.....	.....	.....	.....	.....	M.
9	11.50 a. m.	434.9	1,423	8,490	1.514	12,857.5	23.531	12.9	152	.....	.....	.....	.....	.....	.....	.....	M.
10	10.15 a. m.	434.9	1,423	8,530	1.512	12,897.6	23,571	12 9	.....	40	.....	18	39	27	31	6	M.
11	10.00 a. m.	435.0	1,423	8,450	1.543	13,041.1	23,349	12.8	222	.....	.....	.....	.....	.....	.....	.....	M.
12	9.45 a. m.	435.0	1,423	8,420	1.478	12,460.4	23,319	12.8	30	.....	.....	.....	.....	.....	.....	.....	M.

	14	10.45 a. m.	434.7	1,418	8,110	1.467	11,900.0	23,435	12.8	.....	116	.....	.....	.....	.....	.....		M.
	15	9.15 a. m.	434.6	1,414	7,950	1.464	11,639.4	23,275	12.8	160	.....	.....	.....	.....	.....	.....		M.
	16	9.40 a. m.	434.7	1,417	7,960	1.514	12,055.5	23,144	12.7	134	.....	.....	.....	.....	.....	.....		M.
	17	10.15 a. m.	434.6	1,414	8,000	1.444	11,553.6	23,326	12.8	.....	182	.....	10	18	43	22	5	M.
	18	10.05 a. m.	434.5	1,414	8,010	1.483	11,879.0	23,194	12.7	132	.....	.....	.....	.....	.....	.....	.....	M.
	19	10.00 a. m.	434.6	1,414	8,100	1.512	12,254.3	23,143	12.7	51	.....	.....	.....	.....	.....	.....	.....	M.
	21	10.13 a. m.	434.7	1,415	8,180	1.506	12,327.0	23,081	12.6	62	.....	.....	.....	.....	.....	.....	.....	M.
	22	9.05 a. m.	434.7	1,415	8,210	1.500	12,318.6	23,111	12.7	.....	30	.....	.....	.....	.....	.....	.....	M.
	23	9.45 a. m.	434.7	1,415	8,230	1.555	12,803.6	23,131	12.7	.....	20	.....	.....	.....	.....	.....	.....	M.
	24	9.55 a. m.	434.5	1,406	7,900	1.470	11,616.2	23,072	12.6	59	.....	.....	65	5	26	25	6	M.
	25	10.15 a. m.	434.4	1,406	7,850	1.428	11,196.0	23,163	12.7	.....	91	.....	.....	.....	.....	.....	.....	M.
	26	9.30 a. m.	434.6	1,408	8,015	1.496	11,992.0	22,886	12.5	277	.....	.....	.....	.....	.....	.....	.....	M.
	28	11.40 a. m.	434.8	1,423	8,450	1.543	13,048.3	23,039	12.6	.....	153	.....	.....	.....	.....	.....	.....	M.
Mar.	1	9.40 a. m.	434.7	1,422	8,420	1.546	12,999.9	23,151	12.7	.....	112	.....	.....	.....	.....	.....	.....	M.
	2	9.55 a. m.	434.7	1,422	8,340	1.502	12,675.3	23,171	12.7	80	.....	.....	.....	.....	.....	.....	.....	M.
	3	10.10 a. m.	434.8	1,422	8,520	1.529	12,957.1	23,009	12.6	62	.....	.....	1	11	9	8	1	M.
	4	10.05 a. m.	434.8	1,422	8,340	1.523	12,701.5	22,829	12.5	180	.....	.....	.....	.....	.....	.....	.....	M.
	5	10.10 a. m.	434.7	1,421	8,380	1.467	12,297.0	23,011	12.6	.....	182	.....	.....	.....	.....	.....	.....	M.
	7	10.05 a. m.	434.7	1,422	8,520	1.457	12,404.2	23,151	12.7	.....	140	.....	.....	.....	.....	.....	.....	M.
	8	9.45 a. m.	434.8	1,421	8,600	1.512	13,010.4	23,089	12.7	62	.....	.....	.....	.....	.....	.....	.....	M.
	9	10.05 a. m.	434.8	1,421	8,680	1.510	13,111.1	23,169	12.7	.....	80	.....	.....	.....	.....	.....	.....	M.
	10	9.25 a. m.	434.8	1,421	8,780	1.443	12,574.5	23,269	12.7	.....	100	.....	9	22	9	16	3	M.
	11	10.25 a. m.	434.9	1,422	8,870	1.462	12,975.8	23,217	12.7	52	.....	.....	.....	.....	.....	.....	.....	M.
	12	10.45 a. m.	434.9	1,422	8,880	1.498	13,300.3	23,227	12.7	.....	10	.....	.....	.....	.....	.....	.....	M.
	14	10.00 a. m.	435.2	1,434	9,270	1.509	13,991.7	23,189	12.2	38	.....	.....	.....	.....	.....	.....	.....	M.
	15	9.00 a. m.	435.3	1,437	9,540	1.549	14,783.0	23,315	12.8	.....	126	.....	.....	.....	.....	.....	.....	M.
	16	9.45 a. m.	435.4	1,439	9,700	1.572	15,249.0	23,331	12.8	.....	16	.....	.....	.....	.....	.....	.....	M.
	17	9.05 a. m.	435.7	1,441	9,890	1.597	15,798.9	23,377	12.8	.....	46	.....	19	3	14	10	2	M.
	18	9.25 a. m.	436.4	1,442	10,030	1.577	15,793.5	23,517	12.9	.....	140	.....	.....	.....	.....	.....	.....	M.
	19	8.55 a. m.	436.5	1,443	10,110	1.643	16,616.8	23,453	12.9	64	.....	.....	.....	.....	.....	.....	.....	M.
	21	9.55 a. m.	436.5	1,450	10,125	1.639	16,603.9	23,468	12.9	.....	15	.....	.....	.....	.....	.....	.....	M.
	22	8.50 a. m.	436.7	1,453	10,350	1.619	16,778.7	23,403	12.8	65	.....	.....	.....	.....	.....	.....	.....	M.
	23	9.15 a. m.	436.8	1,455	10,610	1.652	17,532.9	23,517	12.9	.....	114	.....	.....	.....	.....	.....	.....	M.
	24	10.25 a. m.	437.3	1,455	10,810	1.674	18,104.1	23,571	12.9	.....	54	.....	17	9	8	11	2	M.
	25	.....	438.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	M.
	26	.....	438.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	M.
Apr.	8	10.45 a. m.	435.9	1,504	10,620	2.040	21,672.7	26,364	14.4	.....	2,793	.....	9	13	7	11	2	R.
	9	9.30 a. m.	435.8	1,504	10,540	2.128	22,434.7	26,434	14.5	.....	70	.....	.....	.....	.....	.....	.....	R.
	11	9.40 a. m.	435.9	1,504	10,930	2.053	22,446.0	26,674	14.6	.....	240	.....	.....	.....	.....	.....	.....	R.
	12	9.10 a. m.	436.0	1,544	11,370	2.138	24,311.7	26,962	14.8	.....	288	.....	.....	.....	.....	.....	.....	R.
	13	11.15 a. m.	436.2	1,516	11,230	2.208	24,802.5	26,416	14.5	546	.....	.....	11	20	13	16	3	R.
	14	10.45 a. m.	436.5	1,521	11,470	2.224	25,518.4	26,200	14.4	216	.....	.....	.....	.....	.....	.....	.....	R.
	15	9.00 a. m.	436.6	1,521	11,650	2.386	27,786.5	26,228	14.4	.....	28	.....	.....	.....	.....	.....	.....	R.
	16	8.50 a. m.	436.8	1,525	11,780	2.327	27,417.0	26,053	14.3	175	.....	0.0989	.....	.....	.....	.....	.....	R.
	18	4.50 p. m.	437.1	1,537	12,280	2.308	28,342.6	26,094	14.3	.....	41	.....	.....	.....	.....	.....	.....	R.
	19	11.10 a. m.	437.3	1,540	12,490	2.395	29,920.3	25,996	14.2	98	.....	.....	.....	.....	.....	.....	.....	R.
	20	9.10 a. m.	437.6	1,550	12,850	2.435	31,208.6	25,891	14.2	105	.....	.....	17	15	22	17	4	R.
	21	9.35 a. m.	438.0	1,700	13,510	2.632	35,568.8	25,901	14.2	.....	10	.....	.....	.....	.....	.....	.....	R.
	22	10.20 a. m.	438.4	1,753	14,660	2.744	40,227.6	26,358	14.4	.....	459	.....	.....	.....	.....	.....	.....	R.
	23	9.35 a. m.	438.9	1,731	14,780	2.827	41,797.6	25,609	14.6	751	.....	0.0984	.....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT WINONA, MINN.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C. ft. pr. sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Apr. 25	9.30 a. m.	439.7	1,764	16,550	3.041	50,336.2	25,979	14.2	.....	370	.....	.....	.....	.....	.....	.....	R.
26	10.05 a. m.	440.0	1,766	16,890	3.110	52,544.0	25,788	14.1	191	.....	.....	.....	.....	.....	.....	.....	R.
27	10.00 a. m.	440.3	1,774	17,670	3.189	56,359.6	26,037	14.3	.....	249	.....	21	15	31	20	4	R.
28	9.35 a. m.	440.9	1,783	18,920	3.285	62,156.2	26,229	14 4	.....	182	.....	.....	.....	.....	....	.....	R.
29	3.30 p. m.	441.9	1,800	20,780	3.408	70,824.8	26,287	14.4	.....	68	.....	.....	.....	.....	.....	.....	R.
May 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	21	20	4	R
9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26	17	19	20	4	R.
13	9.50 a. m.	442.8	1,803	23,570	3.136	73,924.9	27,455	15.0	.....	1,168	.....	.....	.....	.....	.....	.....	R.
16	4.55 p. m.	442.6	1,800	22,680	3.372	76,475.1	26,925	14.8	530	.....	0.0993	.....	.....	...	.....	.....	R.
17	9.10 a. m.	442.5	1,811	22,990	3.281	75,470.7	27,416	15.0	.....	491	.....	23	29	32	28	6	R.
18	9.55 a. m.	442.5	1,812	22,920	3.279	75,157.8	27,346	15.0	70	.....	.....	.....	.....	.....	.....	.....	R.
19	11.15 a. m.	442.6	1,812	22,710	3.337	75,797.7	26,955	14.8	391	.....	.....	.....	.....	.....	.....	.....	R.
20	10.25 a. m.	442.6	1,812	22,980	3.334	76,629.7	27,225	14.9	.....	270	.....	.....	.....	.....	.....	.....	R.
21	9.45 a. m.	442.5	1,811	22,690	3.306	75,032.1	27,116	14.8	109	.....	.....	.....	.....	.....	.....	.....	R.
23	9.40 a. m.	442.3	1,803	21,880	3.244	70,981.8	26,668	14.6	448	.....	.....	.....	.....	.....	.....	.....	R.
24	10.30 a. m.	442.1	1,799	21,670	3.222	69,832.7	26,818	14.7	.....	150	.....	.....	.....	.....	.....	.....	R.
25	10.45 a. m.	441.9	1,797	21,330	3.253	69,387.4	26,838	14 7	.....	20	0.0977	.....	.....	.....	.....	.....	R.
26	10.00 a. m.	441.7	1,794	20,920	3.171	66,341.4	26,787	14.7	51	.....	.....	25	16	26	21	4	R.
27	10.00 a. m.	441.5	1,791	20,290	3.098	62,876.8	26,516	14.5	271	.....	.....	.....	.....	.....	.....	.....	R.
28	9.55 a. m.	441.3	1,792	20,290	3.065	62,196.7	26,874	14.7	.....	358	.....	.....	.....	.....	.....	.....	R.
30	10.40 a. m.	440.8	1,787	19,370	3.002	58,162.8	26,849	14.7	25	.....	.....	.....	.....	.....	.....	.....	R.
31	3.45 p. m.	440.6	1,782	18,630	2.957	55,102.4	26,466	14.5	383	.....	.....	.....	.....	.....	.....	.....	R.
June 1	3.25 p. m.	440.5	1,782	18,470	2.863	52,894.8	26,484	14.5	.....	18	.....	37	36	33	36	7	R.
2	10.35 a. m.	440.6	1,780	18,355	2.892	53,084.0	26,191	14.4	293	.....	.....	.....	.....	.....	.....	.....	R.
3	10.15 a. m.	440.7	1,783	18,760	2.857	53,602.1	26,418	14.5	.....	227	.....	.....	.....	.....	.....	.....	R.
4	10.30 a. m.	441.0	1,787	19,310	3.051	58,929.3	26,432	14.5	.....	14	0.1020	.....	.....	.....	.....	.....	R.
7	11.20 a. m.	442.1	1,806	21,445	3.218	69,028.4	26,590	14.6	.....	158	0.1234	.....	.....	.....	.....	.....	R.
8	11.45 a. m.	442.1	1,807	21,115	3.243	68,485.7	26,260	14.4	330	.....	0.1141	.....	.....	.....	.....	...	R.
9	11.30 a. m.	442.0	1,804	21,015	3.227	67,847.6	26,340	14.4	.....	80	0.1150	34	26	34	30	7	R.
10	11.15 a. m	442.0	1,802	20,920	3.155	66,012.4	26,245	14.4	95	.....	0.1131	.....	.....	.....	.....	.....	R.
11	11.30 a. m.	441.8	1,801	20,540	3.085	63,366.4	26,225	14.4	20	.....	0.1126	.....	.....	.....	.....	.....	R.
13	11.30 a. m.	441.4	1,796	20,105	3.049	61,311.4	26,509	14.5	.....	284	0.1142	.....	.....	.....	.....	.....	R.
14	11.35 a. m.	441.2	1,793	19,465	3.026	58,911.6	26,228	14.4	281	.....	0.1041	.....	.....	.....	.....	.....	R.
15	12.15 p. m.	440.9	1,790	19,135	2.939	56,244.8	26,435	14.5	.....	207	0.1081	.....	.....	.....	.....	.....	R.
16	10.35 a. m.	440.7	1,785	18,733	2.943	55,133.2	26,391	14.5	44	.....	.....	27	28	25	27	5	R.
17	2.25 p. m.	440.5	1,782	18,245	2.898	52,886.6	26,260	14.4	131	.....	0.1080	.....	.....	.....	.....	.....	R.
18	3.55 p. m.	440.5	1,782	18,280	2.909	53,187.3	26,295	14.4	.....	35	0.1115	.....	.....	.....	.....	.....	R.

	20	11.20 a. m.	440.6	1,785	18,895	2.957	55,891.2	26,732	14.7	.....	437	0.1114	.....	.....	.....	.....	.....	R.
	21	3.15 p. m.	440.7	1,782	18,710	3.004	56,221.6	26,369	14.4	363	.....	0.1087	15	18	35	22	5	R.
	22	3.25 p. m.	440.7	1,782	18,540	2.972	55,110.3	26,199	14.4	170	.....	0.1119	.....	.....	.....	.....	.....	R.
	23	9.20 a. m.	440.7	1,782	18,540	2.964	54,971.2	26,199	14.4	0	0	0.1131	.....	.....	.....	.....	.....	R.
	24	9.50 a. m.	440.8	1,782	18,625	2.920	54,402.8	26,106	14.3	93	.....	0.0958	.....	.....	.....	.....	.....	R.
	25	11.00 a. m.	440.8	1,784	18,780	3.006	56,466.0	26,261	14.4	.....	155	0.0975	.....	.....	.....	.....	.....	R.
	27	5.10 p. m.	440.7	1,784	18,530	2.885	53,469.8	26,189	14.4	72	.....	0.1038	.....	.....	.....	.....	.....	R.
	28	12.10 p. m.	440.5	1,782	18,550	2.889	53,601.1	26,566	14.6	.....	377	0.1075	31	24	26	26	5	R.
	29	4.00 p. m.	440.3	1,778	18,430	2.849	52,524.6	26,802	14.7	....	236	0.1073	.....	.....	.....	.....	.....	R.
	30	1.25 p. m.	440.2	1,775	17,975	2.874	51,662.5	26,525	14.5	277	.....	0.1070	.....	.....	.....	.....	.....	R.
July	1	1.10 p. m.	440.0	1,770	17,645	2.814	49,658.9	26,550	14.5	.....	25	0.1077	.....	.....	.....	.....	.....	R.
	2	10.00 a. m.	440.0	1,767	17,405	2.725	47,443.7	26,310	14.4	240	.....	0.1093	.....	.....	.....	.....	.....	R.
	4	5.15 p. m.	440.0	1,764	17,370	2.820	48,988.4	26,275	14.4	35	.....	0.1108	.....	.....	.....	.....	.....	R.
	5	4.30 p. m.	439.7	1,761	16,945	2.776	47,039.4	26,379	14.5	.....	104	0.1084	2	2	2	2	½	R.
	6	3.55 p. m.	439.6	1,757	16,695	2.725	45,498.3	26,365	14.4	74	.....	0.1088	.....	.....	.....	.....	.....	R.
	7	4.45 p. m.	439.4	1,756	16,560	2.718	45,021.7	26,521	14.5	.....	216	0.1085	.....	.....	.....	.....	.....	R.
	8	2.00 p. m.	439.3	1,755	16,530	2.690	44,479.0	26,667	14.6	.....	146	0.1125	.....	.....	.....	.....	.....	R.
	9	10.30 a. m.	439.1	1,749	16,380	2.673	43,792.7	26,867	14.7	.....	200	0.1107	.....	.....	.....	.....	.....	R.
	11	3.10 p. m.	438.8	1,748	15,690	2.584	40,531.2	26,702	14.6	165	.....	0.1093	.....	.....	.....	.....	.....	R.
	12	3.20 p. m.	438.6	1,748	15,345	2.581	39,612.1	26,707	14.6	.....	5	0.1079	.....	.....	.....	.....	.....	R.
	13	12.05 p. m.	438.3	1,742	15,100	2.488	35,578.0	26,986	14.8	.....	279	0.1101	.....	.....	.....	.....	.....	R.
	14	3.30 p. m.	438.0	1,737	14,525	2.424	35,210.9	26,983	14.8	53	.....	0.1109	2	2	2	2	½	R.
	15	9.10 a. m.	437.9	1,737	14,075	2.437	34,308.5	26,556	14.6	277	.....	0.1116	.....	.....	.....	.....	.....	R.
	16	11.35 a. m.	437.9	1,732	13,985	2.438	34,109.1	26,466	14.5	90	.....	0.1143	.....	.....	.....	.....	.....	R.
	18	3.00 p. m.	438.1	1,740	14,445	2.443	35,295.7	26,579	14.6	.....	113	0.1142	.....	.....	.....	.....	.....	R.
	19	2.30 p. m.	438.2	1,740	14,535	2.481	36,068.7	26,595	14.6	84	.....	0.1142	2	2	2	2	½	R.
	20	3.00 p. m.	438.3	1,740	14,800	2.495	36,929.5	26,686	14.6	.....	91	0.1132	.....	.....	.....	.....	.....	R.
	21	2.15 p. m.	438.5	1,747	15,350	2.556	39,248.5	26,887	14.7	.....	201	0.1053	.....	.....	.....	.....	.....	R.
	22	2.50 p. m.	438.3	1,742	14,960	2.523	37,747.7	26,846	14.7	41	.....	0.1090	2	2	2	2	½	R.
	23	10.10 a. m.	438.2	1,742	14,525	2.482	36,056.2	26,585	14.6	261	.....	0.1123	2	2	2	2	½	R.
	25	2.40 p. m.	438.0	1,739	14,065	2.493	35,068.3	26,473	14.5	112	.....	0.1125	2	2	2	2	½	R.
	26	3.55 p. m.	437.8	1,696	13,625	2.416	32,921.9	26,377	14.5	96	.....	0.1133	.....	.....	.....	.....	.....	R.
	27	10.30 a. m.	437.6	1,601	13,310	2.357	31,379.0	26,392	14.5	.....	15	0.1118	.....	.....	.....	.....	.....	R.
	28	11.20 a. m.	437.4	1,576	12,855	2.352	30,241.0	26,255	14.4	137	.....	0.1123	.....	.....	.....	.....	.....	R.
	29	10.30 a. m.	437.1	1,512	12,770	2.236	28,566.0	26,633	14.6	.....	378	0.1137	.....	.....	.....	.....	.....	R.
	30	11.15 a. m.	437.0	1,459	12,450	2.169	27,011.5	26,462	14.5	171	.....	0.1162	2	2	2	2	½	R.
Aug.	1	10.25 a. m.	436.7	1,441	12,160	2.086	25,372.6	26,607	14.6	.....	145	0.1142	.....	.....	.....	.....	.....	R.
	2	10.50 a. m.	436.6	1,423	11,950	2.062	24,650.6	26,540	14.5	67	.....	0.1123	.....	.....	.....	.....	.....	R.
	3	10.30 a. m.	436.5	1,420	11,795	2.105	24,836.8	26,527	14.5	13	.....	0.1121	.....	.....	.....	.....	.....	R.
	4	9.34 a. m.	436.4	1,418	11,650	2.084	24,286.5	26,524	14.5	3	.....	0.1130	.....	.....	.....	.....	.....	R.
	5	10.20 a. m.	436.4	1,413	11,685	2.061	24,092.7	26,559	14.5	.....	35	0.1153	.....	.....	.....	.....	.....	R.
	6	10.30 a. m.	436.4	1,416	11,630	2.081	24,207.3	26,504	14.5	55	.....	0.1142	.....	.....	.....	.....	.....	R.
	8	2.30 p. m.	436.1	1,383	11,315	1.959	22,169.0	26,609	14.7	.....	105	0.1161	.....	.....	.....	.....	.....	R.
	9	10.40 a. m.	436.4	1,410	11,605	2.084	24,185.5	26,480	14.5	129	.....	0.1160	.....	.....	.....	.....	.....	R.
	10	11.05 a. m.	436.8	1,446	12,175	2.207	26,873.9	26,479	14.5	1	.....	0.1146	.....	.....	.....	.....	.....	R.
	11	11.10 a. m.	437.0	1,467	12,505	2.265	28,331.5	26,518	14.5	.....	39	0.1142	.....	.....	.....	.....	.....	R.
	12	10.30 a. m.	437.0	1,470	12,560	2.285	28,702.3	26,573	14.6	.....	55	0.1146	.....	.....	.....	.....	.....	R.
	13	10.10 a. m.	437.1	1,490	12,758	2.293	29,260.9	26,653	14.6	.....	50	0.1146	.....	.....	.....	.....	.....	R.
	15	11.00 a. m.	436.7	1,436	12,275	2.247	27,583.0	26,725	14.6	.....	102	0.1132	.....	.....	.....	.....	.....	R.
	16	10.20 a. m.	436.5	1,419	11,650	2.179	25,390.8	26,386	14.5	339	.....	0.1130	.....	.....	.....	.....	.....	R.
	17	10.35 a. m.	436.3	1,406	11,280	2.147	24,226.1	26,298	14.4	88	.....	0.1125	....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT WINONA, MINN.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet,*	*Ft. per sec.*	*C. ft. per sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Aug. 18	10. 35 a. m.	436. 4	1, 412	11, 380	2. 202	25, 063. 4	26. 257	14. 4	41	.....	0. 1131	.....	.....	.....	.....	.....	R.
19	10. 55 a. m.	436. 3	1, 409	11, 155	2. 162	24, 123. 1	26, 173	14. 3	84	.....	0. 1144	.....	.....	.....	.....	.....	R.
20	9. 50 a. m.	436. 3	1, 405	10, 920	2. 163	23, 624. 8	25, 938	14. 2	235	.....	0. 1140	.....	.....	.....	.....	.....	R.
22	12. 35 p. m.	436. 3	1, 403	10, 860	2. 131	23, 147. 4	25, 878	14. 2	60	.....	0. 1156	.....	.....	.....	.....	.....	R.
23	12. 40 p. m.	436. 5	1, 408	10, 085	2. 244	24, 883. 6	25, 822	14. 1	56	.....	0. 1155	.....	.....	.....	.....	.....	R.
24	10. 05 a. m.	436. 6	1, 421	11, 300	2. 281	25, 783. 0	25, 896	14. 2	.....	74	0. 1155	.....	.....	.....	.....	.....	R.
25	9. 45 a. m.	436. 8	1, 432	11, 630	2. 287	26, 606. 5	25, 940	14. 2	.....	44	0. 1157	.....	.....	.....	.....	.....	R.
26	12. 40 p. m.	437. 0	1, 454	11, 835	2. 380	28, 171. 7	25, 856	14. 2	84	.....	0. 1150	.....	.....	.....	.....	.....	R.
27	10. 30 a. m.	437. 3	1, 529	12, 280	2. 496	30, 653. 3	25, 853	14. 2	3	.....	0. 1178	.....	.....	.....	.....	.....	R.
29	12. 55 p. m.	437. 3	1, 522	12, 450	2. 493	31, 044. 6	26, 023	14. 3	.....	170	0. 1164	.....	.....	.....	.....	.....	R.
30	12. 40 p. m.	437. 9	1, 668	13, 350	2. 616	34, 934. 8	25, 967	14. 2	56	.....	0. 1186	.....	.....	.....	.....	.....	R.
31	10. 15 a. m.	438. 6	1, 741	14, 815	2. 705	40, 067. 3	26, 238	14. 4	.....	271	0. 1203	.....	.....	.....	.....	.....	R.
Sept. 1	12. 00 m.	439. 4	1, 750	16, 285	2. 902	47, 269. 5	26, 311	14. 4	.....	73	0. 1202	.....	.....	.....	.....	.....	R.
2	10. 30 a. m.	439. 9	1, 760	17, 315	3. 028	52, 443. 2	26, 463	14. 5	.....	152	0. 1186	.....	.....	.....	.....	.....	R.
3	11. 10 a. m.	440. 2	1, 776	18, 085	3. 079	55, 685. 6	26, 703	14. 6	.....	240	0. 1223	.....	.....	.....	.....	.....	R.
5	1. 34 p. m.	440. 0	1, 768	17, 810	3. 027	53, 912. 5	26, 782	14. 7	.....	79	0. 1193	.....	.....	.....	.....	.....	R.
6	11. 00 a. m.	440. 0	1, 769	18, 015	2. 992	53, 918. 8	26, 987	14. 8	.....	205	0. 1172	.....	.....	.....	.....	.....	R.
7	10. 50 a. m.	439. 9	1, 767	17, 915	2. 920	53, 327. 8	27, 064	14. 8	.....	77	0. 1066	.....	.....	.....	.....	.....	R.
8	12. 10 p. m.	439. 7	1, 766	17, 130	2. 952	50, 577. 8	26, 632	14. 6	432	.....	0. 1048	.....	.....	.....	.....	.....	R.
9	10. 10 a. m.	439. 6	1, 765	16, 685	2. 849	47, 538. 2	26, 364	14. 4	268	.....	0. 1064	.....	.....	.....	.....	.....	R.
10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0. 1053	.....	.....	.....	.....	.....	R.
12	2. 10 p. m.	441. 1	1, 781	18, 555	3. 208	59, 527. 5	25, 574	14. 0	790	.....	0. 1141	.....	.....	.....	.....	.....	R.
13	3. 15 p. m.	442. 0	1, 798	20, 145	3. 307	66, 630. 5	25, 553	14. 0	21	.....	0. 1123	.....	.....	.....	.....	.....	R.
14	12. 05 p. m.	442. 7	1, 810	21, 520	3. 380	72, 737. 4	25, 664	14. 1	.....	111	0. 1159	.....	.....	.....	.....	.....	R.
15	12. 45 p. m.	443. 4	1, 816	23, 320	3. 523	82, 159. 4	26, 195	14. 4	.....	531	0. 1140	.....	.....	.....	.....	.....	R.
16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0. 1149	.....	.....	.....	.....	.....	R.
17	3. 25 p. m.	444. 3	1, 825	25, 245	3. 595	90, 771. 0	26, 481	14. 5	.....	286	0. 1148	.....	.....	.....	.....	.....	R.
19	3. 30 p. m.	444. 2	1, 823	25, 060	3. 567	89, 390. 7	26, 478	14. 5	3	.....	0. 1141	.....	.....	.....	.....	.....	R.
20	11. 55 a. m.	444. 2	1, 823	24, 955	3. 549	88, 572. 3	26, 373	14. 5	105	.....	0. 1132	.....	.....	.....	.....	.....	R.
21	10. 45 a. m.	444. 2	1, 820	24, 945	3. 553	88, 643. 8	26, 363	14. 4	10	.....	0. 1146	.....	.....	.....	.....	.....	R.
22	12. 34 p. m.	444. 2	1, 820	25, 035	3. 541	88, 671. 8	26, 453	14. 5	.....	90	0. 1146	.....	.....	.....	.....	.....	R.
23	12. 30 p. m.	444. 1	1, 819	24, 740	3. 535	87, 568. 8	26, 340	14. 4	113	.....	0. 1122	.....	.....	.....	.....	.....	R.
24	10. 30 a. m.	444. 0	1, 818	24, 505	3. 519	86, 239. 7	26, 293	14. 4	53	.....	0. 1132	.....	.....	.....	.....	.....	R.
26	12. 05 p. m.	443. 7	1, 818	23, 915	3. 453	82, 577. 2	26, 242	14. 4	45	.....	0. 1157	.....	.....	.....	.....	.....	R.
27	1. 53 p. m.	443. 6	1, 814	23, 655	3. 431	81, 168. 2	26, 164	14. 3	78	.....	0. 1119	.....	.....	.....	.....	.....	R.
28	12. 10 p. m.	443. 8	1, 814	23, 785	3. 433	81, 675. 6	25, 931	14. 2	233	.....	0. 1144	.....	.....	.....	.....	.....	R.

29	12.15 p.m.	444.3	1,820	24,710	3.530	87,229.7	25,947	14.2	.....	16	0.1187	.....	.....	.....	.....	.....	R.
30	11.25 a.m.	444.8	1,822	25,995	3.601	93,622.7	26,321	14.4	.....	374	0.1156	.....	.....	.....	.....	.....	R.
Oct. 1	10.15 a.m.	445.0	1,824	26,445	3.638	96,220.9	26,407	14.5	.....	86	0.1156	.....	.....	.....	.....	.....	R.
3	10.30 a.m.	445.4	1,825	27,335	3.794	103,711.8	26,567	14.6	.....	160	0.1156	.....	.....	.....	.....	.....	R.
12	.....	445.7	2,064	27,605	4.024	111,102.7	26,253	14.4	314	.....	.....	.....	.....	.....	.....	.....	R.
13	.....	445.8	2,066	27,695	4.112	113,883.2	26,136	14.3	117	.....	.....	.....	.....	.....	.....	.....	R.
14	.....	446.0	2,068	28,410	4.135	117,476.5	26,438	14.5	.....	302	.....	.....	.....	.....	.....	.....	R.
15	.....	446.5	2,075	29,555	4.312	127,441.3	26,547	14.5	.....	109	.....	.....	.....	.....	.....	.....	R.
17	.....	446.7	2,090	29,835	3.954	117,993.0	26,410	14.5	137	.....	.....	.....	.....	.....	.....	.....	R.
18	.....	446.5	2,088	29,510	4.068	120,049.8	26,525	14.5	.....	115	.....	.....	.....	.....	.....	.....	R.
19	.....	446.1	2,084	28,945	3.925	113,612.6	26,794	14.7	.....	269	.....	.....	.....	.....	.....	.....	R.
20	.....	445.8	1,993	28,350	3.773	106,988.3	26,811	14.7	.....	17	.....	.....	.....	.....	.....	.....	R.
21	.....	445.6	1,973	27,695	3.697	102,389.5	26,513	14.5	298	.....	.....	.....	.....	.....	.....	.....	R.
22	.....	445.1	1,838	27,380	3.662	100,291.6	27,151	14.9	.....	638	.....	.....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT CLAYTON, IOWA.

1880																	
Dec. 7	12.30 p.m.	3.61	1,455	18,735.2	1.264	23,679.2	41,453	27.9	.....	.....	.....	.....	.....	.....	.....	.....	M.
9	3.30 p.m.	2.71	1,455	18,623.3	1.193	22,225.3	41,501	27.9	.....	48	.....	.....	.....	.....	.....	.....	M.
10	2.00 p.m.	2.45	1,455	19,024.8	1.115	21,217.0	40,766	27.4	735	.....	.....	.....	.....	.....	.....	.....	M.
11	.....	2.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	M.
14	12.30 p.m.	2.11	1,455	18,841.5	1.162	21,910.8	40,903	27.5	.....	137	.....	.....	.....	.....	.....	.....	M.
15	12.30 p.m.	2.18	1,455	18,826.4	1.206	22,694.5	40,742	27.4	161	.....	.....	.....	.....	.....	.....	.....	M.
16	10.15 a.m.	2.22	1,455	18,977.7	1.236	23,460.9	40,791	27.4	.....	49	.....	.....	.....	.....	.....	.....	M.
17	11.00 a.m.	2.27	1,455	19,036.0	1.265	24,081.2	40,733	27.4	58	.....	.....	.....	.....	.....	.....	.....	M.
18	11.00 a.m.	2.27	1,455	19,158.1	1.264	24,210.6	40,811	27.4	.....	78	.....	.....	.....	.....	.....	.....	M.
20	10.30 a.m.	2.17	1,455	19,061.8	1.258	23,983.5	40,773	27.4	38	.....	.....	.....	.....	.....	.....	.....	M.
21	11.00 a.m.	2.06	1,455	18,977.0	1.241	23,550.5	40,799	27.4	.....	17	.....	.....	.....	.....	.....	.....	M.
22	10.00 a.m.	1.96	1,455	18,769.3	1.236	23,192.6	40,669	27.3	121	.....	.....	.....	.....	.....	.....	.....	M.
23	11.00 a.m.	1.86	1,455	18,695.9	1.231	23,020.6	40,683	27.3	.....	14	.....	.....	.....	.....	.....	.....	M.
24	11.00 a.m.	1.77	1,455	18,539.6	1.211	22,443.4	40,600	27.3	83	.....	.....	.....	.....	.....	.....	.....	M.
27	11.30 a.m.	1.64	1,453	18,447.6	1.166	21,502.3	40,581	27.3	19	.....	.....	.....	.....	.....	.....	.....	M.
30	3.45 p.m.	1.44	1,453	18,270.9	1.101	20,120.7	40,549	27.2	32	.....	.....	.....	.....	.....	.....	.....	M.
31	.....	1.01	1,448	17,838.0	1.026	18,306.0	40,549	27.2	.....	104	.....	.....	.....	.....	.....	.....	M.
1881.																	
Jan. 1	11.00 a.m.	0.40	1,448	17,347.8	0.946	16,397.5	40,928	27.5	.....	275	.....	.....	.....	.....	.....	.....	M.
4	10.30 a.m.	0.38	1,448	17,422.6	0.995	17,343.6	41,119	27.6	.....	191	.....	.....	.....	.....	.....	.....	M.
5	10.00 a.m.	0.63	1,448	17,642.9	1.030	18,179.0	41,006	27.6	113	.....	.....	.....	.....	.....	.....	.....	M.
6	11.00 a.m.	0.79	1,450	17,920.0	1.079	19,325.5	41,078	27.6	.....	72	.....	.....	.....	.....	.....	.....	M.
7	11.00 a.m.	0.93	1,450	17,999.2	1.087	19,566.6	40,997	27.6	81	.....	.....	.....	.....	.....	.....	.....	M.
8	11.00 a.m.	1.01	1,450	18,130.5	1.086	19,700.2	41,041	27.6	.....	44	.....	.....	.....	.....	.....	.....	M.
10	11.30 a.m.	1.07	1,450	18,209.6	1.086	19,785.5	41,033	27.6	8	.....	.....	.....	.....	.....	.....	.....	M.
11	11.30 a.m.	1.07	1,450	18,249.8	1.091	19,913.3	41,073	27.6	.....	40	.....	.....	.....	.....	.....	.....	M.
12	12.15 a.m.	1.03	1,450	18,218.3	1.092	19,800.4	41,099	27.6	.....	26	.....	.....	.....	0	.....	0	M.
13	11.00 a.m.	1.00	1,450	18,218.2	1.076	19,611.7	41,143	27.6	.....	44	.....	.....	.....	.....	.....	.....	M.
14	12.45 p.m.	1.00	1,450	18,209.5	1.063	19,351.7	41,134	27.6	9	.....	.....	.....	.....	.....	.....	.....	M.
15	12.30 p.m.	0.99	1,450	18,209.5	1.057	19,252.4	41,134	27.6	0	0	.....	.....	.....	.....	.....	.....	M.
17	12.00 m.	0.84	1,450	17,954.5	1.046	18,787.5	41,011	27.6	123	.....	.....	.....	.....	.....	.....	.....	M.

CURRENT AND SEDIMENT OBSERVATIONS AT CLAYTON, IOWA.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C. ft. per sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Jan. 18	12.00 m.	0.76	1,450	17,893.6	1.018	18,219.7	41,023	27.6	.....	12	.....	.....	.....	.....	.....	.....	M.
19	11.45 a. m.	0.73	1,450	17,893.6	1.016	18,182.7	41,008	27.6	15	.....	.....	.....	.....	.....	.....	.....	M.
20	11.45 a. m.	0.71	1,450	17,893.6	1.019	18,242.2	40,993	27.6	15	.....	.....	.....	.....	.....	.....	.....	M.
21	9.45 a. m.	0.68	1,450	17,893.6	1.030	18,432.1	40,993	27.6	0	0	.....	.....	.....	.....	.....	.....	M.
22	9.45 a. m.	0.63	1,450	17,758.0	1.015	18,018.7	40,872	27.5	121	.....	.....	.....	.....	.....	.....	.....	M.
26	11.00 a. m.	0.72	1,444	17,721.6	1.051	18,633.2	40,706	27.4	166	.....	.....	.....	.....	.....	.....	.....	M.
27	10.00 a. m.	0.74	1,442	17,718.3	1.036	18,358.9	40,674	27.3	32	.....	.....	.....	.....	.....	.....	.....	M.
28	11.00 a. m.	0.72	1,439	17,605.5	1.025	18,045.5	40,575	27.3	99	.....	.....	.....	.....	19	19	4	M.
29	12.45 p. m.	0.65	1,439	17,487.0	1.034	18,078.1	40,542	27.2	33	.....	.....	.....	.....	.....	.....	.....	M.
31	12.00 m.	0.46	1,439	17,312.0	1.012	17,516.4	40,612	27.3	.....	70	.....	.....	.....	.....	.....	.....	M.
Feb. 1	11.00 a. m.	0.50	1,438	17,259.9	1.008	17,396.3	40,488	27.2	124	.....	.....	.....	.....	.....	.....	.....	M.
2	11.40 a. m.	0.53	1,438	17,294.4	1.011	17,477.2	40,465	27.2	23	.....	.....	.....	.....	6	6	1	M.
3	11.30 a. m.	0.54	1,438	17,408.1	1.010	17,574.4	40,550	27.3	.....	85	.....	.....	.....	.....	.....	.....	M.
4	11.30 a. m.	0.54	1,438	17,372.9	1.023	17,772.6	40,486	27.2	64	.....	.....	.....	.....	.....	.....	.....	M.
5	11.40 a. m.	0.52	1,438	17,359.7	1.013	17,582.8	40,473	27.2	13	.....	.....	.....	.....	.....	.....	.....	M.
7	12.30 p. m.	0.50	1,438	17,211.5	1.007	17,317.8	40,296	27.1	177	.....	.....	.....	.....	.....	.....	.....	M.
8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	5	10	6	1	M.
9	12.00 m.	0.47	1,438	17,347.9	1.014	17,596.7	40,418	27.2	.....	122	.....	.....	.....	.....	.....	.....	M.
10	11.15 a. m.	0.50	1,438	17,268.7	1.037	17,909.1	40,267	27.1	151	.....	.....	.....	.....	.....	.....	.....	M.
11	10.45 a. m.	0.54	1,438	17,396.3	1.044	18,161.6	40,294	27.1	.....	27	.....	.....	.....	.....	.....	.....	M.
14	12.15 p. m.	0.68	1,438	17,312.7	1.055	18,262.8	39,923	26.8	371	.....	.....	.....	.....	.....	.....	.....	M.
15	11.00 a. m.	0.68	1,438	17,356.7	1.036	17,978.4	39,953	26.8	.....	30	.....	6	7	2	6	1	M.
16	12.00 m.	0.62	1,438	17,325.9	1.038	17,990.7	39,980	26.9	.....	27	.....	.....	.....	.....	.....	.....	M.
17	10.45 a. m.	0.55	1,438	17,347.2	1.030	17,872.5	40,073	26.9	.....	93	.....	.....	.....	.....	.....	.....	M.
18	10.45 a. m.	0.53	1,438	17,272.4	1.030	17,792.3	39,998	26.9	75	.....	.....	.....	.....	.....	.....	.....	M.
19	11.00 a. m.	0.52	1,438	17,303.2	1.023	17,707.1	40,015	26.9	.....	17	.....	.....	.....	...	.....	.....	M.
21	12.00 m.	0.51	1,438	17,282.6	1.039	17,955.0	39,981	26.9	34	.....	.....	.....	.....	.....	.....	.....	M.
22	10.45 a. m.	0.55	1,438	17,396.3	1.047	18,209.2	40,022	26.9	.....	41	.....	5	7	9	7	1	M.
23	9.30 a. m.	0.58	1,438	17,369.9	1.057	18,358.9	39,938	26.8	84	.....	.....	.....	.....	.....	.....	.....	M.
24	9.30 a. m.	0.62	1,438	17,505.6	1.078	18,869.8	40,001	26.9	.....	63	.....	.....	.....	.....	.....	.....	M.
25	9.15 a. m.	0.64	1,438	17,492.4	1.076	18,826.0	39,945	26.8	56	.....	.....	.....	.....	.....	.....	.....	M.
26	9.35 a. m.	0.63	1,438	17,509.3	1.074	18,813.6	39,965	26.9	.....	17	.....	.....	.....	....	.....	.....	M.
28	9.15 a. m.	0.57	1,438	17,405.1	1.058	18,408.9	39,944	26.8	18	.....	.....	.....	.....	.....	.....	.....	M.
Mar. 1	9.30 a. m.	0.63	1,438	17,474.8	1.069	18,680.1	39,927	26.8	17	.....	.....	.....	.....	.....	.....	.....	M.
4	9.30 a. m.	0.93	1,438	17,809.9	1.112	19,808.2	39,874	26.8	53	.....	.....	.....	.....	.....	.....	.....	M.
5	9.15 a. m.	0.90	1,438	17,822.4	1.119	19,937.2	39,886	26.8	.....	12	.....	36	31	6	26	5	M.
7	9.20 a. m.	0.87	1,438	17,751.3	1.123	19,929.1	39,858	26.8	28	.....	.....	.....	.....	.....	.....	.....	M.

	8	9.15 a. m.	0.82	1,438	17,737.4	1.121	19,891.2	39,916	26.8	.....	58	.....	.....	.....	.....	.....	M.
	9	9.00 a. m.	0.81	1,438	17,746.2	1.101	19,542.9	39,939	26.8	.....	23	.....	.....	.....	.....	.....	M.
	10	8.50 a. m.	0.82	1,438	17,812.2	1.117	19,889.9	39,991	26.8	.....	52	.....	26	8	8	13	3	M.
	11	9.30 a. m.	0.92	1,438	17,873.1	1.116	19,953.0	39,923	26.8	68	.....	.....	.....	.....	.....	.....	.....	M.
	12	9.30 a. m.	1.03	1,438	18,022.0	1.132	20,401.6	39,813	26.8	110	.....	.....	.....	.....	.....	.....	.....	M.
	14	9.50 a. m.	1.30	1,438	18,380.7	1.171	21,529.1	39,755	26.7	58	.....	.....	.....	.....	.....	.....	.....	M.
	15	9.35 a. m.	1.45	1,438	18,630.1	1.198	22,321.0	39,774	26.7	.....	19	.....	21	12	49	24	5	M.
	16	9.15 a. m.	1.55	1,438	18,783.4	1.205	22,625.9	39,769	26.7	5	.....	.....	.....	.....	.....	.....	.....	M.
	17	9.50 a. m.	1.61	1,438	18,888.3	1.248	23,573.5	39,773	26.7	.....	4	.....	13	10	3	9	2	M.
	18	9.15 a. m.	1.68	1,438	18,923.5	1.280	24,214.3	39,693	26.7	80	.....	.....	.....	.....	.....	.....	.....	M.
	19	9.20 a. m.	1.75	1,438	19,059.2	1.296	24,694.3	39,600	26.6	...	7	....	1	9	7	7	1	M.
	21	11.30 a. m.	2.17	1,438	19,505.2	1.368	26,683.2	39,600	26.6	100	.....	.....	11	28	16	21	4	M.
	22	11.45 a. m.	2.45	1,438	19,807.4	1.430	28,125.5	39,542	26.6	58	.....	....	.....	.....	.....	.....	.....	M.
	23	9.15 a. m.	2.69	1,438	20,132.3	1.477	29,739.0	39,565	26.6	.....	23	.....	.....	.....	.....	.....	.....	M.
	24	10.15 a. m.	3.01	1,452	20,670.8	1.513	31,268.5	39,686	26.6	.....	121	....	25	20	17	21	4	M.
	25	10.15 a. m.	3.57	1,452	21,351.0	1.603	34,218.5	39,597	26.6	89	.....	.....	.....	.....	.....	.....	....	M.
	26	10.30 a. m.	4.10	1,455	22,218.5	1.660	36,884.9	39,735	26.7	.....	138	.....	42	28	18	29	6	M.
	28	9.45 a. m.	4.95	1,459	23,641.1	1.802	42,603.6	40,006	26.9	.....	271	.....	19	15	13	16	3	M.
Apr.	12	12.56 p. m.	4.83	1,459	23,171.8	2.160	50,051.1	42,688	28.7	.....	2,682	.....	.....	.....	.....	.....	.....	R.
	13	10.56 a. m.	4.64	1,459	22,939.4	2.088	47,918.9	42,733	28.7	.....	45	.....	.....	.....	.....	.....	.....	R.
	15	11.32 a. m.	4.56	1,459	22,878.9	2.146	49,207.6	42,790	28.8	.....	57	....	.....	.....	.....	.....	.....	R.
	18	11.05 a. m.	5.25	1,460	23,986.4	2.245	53,958.1	42,890	28.8	.....	100	....	16	9	9	11	2	R.
	21	10.46 a. m.	5.77	1,462	24,671.1	2.383	58,803.2	42,815	28.8	75	.....	.....	6	1	9	4	1	R.
	22	9.57 a. m.	6.00	1,463	24,898.9	2.440	60,765.4	42,707	28.7	108	.....	....	10	7	7	8	2	R.
	23	9.10 a. m.	6.23	1,464	25,237.8	2.524	63,710.0	42,709	28.7	... ..	2	.....	4	9	4	7	1	R.
	25	9.24 a. m.	6.58	1,465	25,556.2	2.607	66,628.7	42,515	28.6	194	.....	....	3	7	10	7	1	R.
	26	10.44 a. m.	6.73	1,466	25,755.4	2.610	67,230.6	42,494	28.6	21	.....	.....	.....	.....	.....	.....	.....	R.
	28	10.26 a. m.	7.10	1,469	26,308.0	2.759	72,585.3	42,504	28.6	.. ...	10	.....	.....	.....	.....	.....	.....	R.
	29	11.10 a. m.	7.31	1,470	26,577.1	2.771	73,643.0	42,465	28.5	39	.....	.....	24	17	12	18	4	R.
May	2	10.10 a. m.	8.26	1,470	27,667.2	2.725	75,393.1	42,158	28.3	307	.....	.....	.....	.....	.....	.....	.....	R.
	3	10.50 a. m.	9.10	1,471	29,471.2	3.328	98,080.2	42,727	28.7	.....	569	.....	.....	.....	.....	.....	.....	R.
	5	10.00 a. m.	12.21	1,473	33,836.0	4.007	135,580.8	42,499	28.6	228	.....	.....	26	26	21	25	5	R.
	7	11.25 a. m.	13.73	1,483	35,895.2	4.001	143,626.2	42,304	28.4	195	.....	.....	.....	.....	.....	.....	.....	R.
	10	10.00 a. m.	13.51	1,483	35,279.2	3.893	137,342.0	42,014	28.2	290	.....	.....	.....	.....	.....	.....	.....	R.
	11	9.40 a. m.	13.08	1,483	35,350.4	3.814	134,826.5	42,723	28.7	.....	709	.....	.....	.....	.....	.....	.....	R.
	12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	9	3	7	1	R.
	16	12.10 p. m.	11.07	1,478	32,322.4	3.529	114,065.7	42,672	28.7	51	.....	.....	.....	.....	.....	.....	.....	R.
	17	9.30 a. m.	10.87	1,478	31,759.2	3.526	111,983.0	42,405	28.5	267	.....	....	.....	.....	.....	.....	.....	R.
	18	9.25 a. m.	10.68	1,478	31,486.4	3.450	108,628.0	42,397	28.4	8	.....	.....	.....	.....	.....	.....	.....	R.
	19	10.10 a. m.	10.54	1,478	31,372.0	3.414	107,104.0	42,490	28.6	.....	93	.....	3	5	8	5	1	R.
	20	10.45 a. m.	10.40	1,478	31,416.0	3.420	107,442.8	42,741	28.7	.....	251	.....	.....	.....	.....	.....	.....	R.
	21	9.00 a. m.	10.30	1,477	31,046.4	3.378	104,875.0	42,519	28.6	222	.....	.....	.....	.....	.....	.....	.....	R.
	23	9.30 a. m.	10.14	1,477	30,483.2	3.208	97,790.1	42,192	28.4	327	.....	.....	.....	.....	.....	.....	.....	R.
	24	10.00 a. m.	9.96	1,476	30,474.4	3.203	97,609.5	42,449	28.5	.....	257	.....	.....	.....	.....	.....	.....	R.
	25	9.00 a. m.	9.82	1,476	30,087.2	3.197	96,299.5	42,268	28.4	181	.....	.....	.....	.....	.....	.....	.....	R.
	26	9.30 a. m.	9.58	1,475	29,833.9	3.162	94,334.9	42,369	28.5	.....	101	.....	3	3	2	3	1	R.
	27	9.25 a. m.	9.40	1,475	29,585.6	3.100	91,715.4	42,386	28.4	.....	17	.....	.....	.....	.....	.....	.....	R.
	28	10.15 a. m.	9.15	1,474	29,664.8	3.072	91,130.3	42,834	28.8	.....	448	.....	.....	.....	.....	.....	.....	R.
	30	9.00 a. m.	8.76	1,473	28,670.4	2.953	84,658.4	42,414	28.5	420	.....	.....	.....	.....	.....	.....	.....	R.
	31	9.00 a. m.	8.55	1,472	28,151.2	3.010	84,735.1	42,204	28.4	210	.....	.....	.....	.....	.....	.....	.....	R.
une	1	8.50 a. m.	8.35	1,471	27,816.8	2.598	72,268.0	42,164	28.3	40	....	.....	8	7	10	8	2	R.

J

CURRENT AND SEDIMENT OBSEBVATIONS AT CLAYTON, IOWA—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C. ft. pr. sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
June 2	8. 50 a. m.	8. 10	1, 470	27, 667. 2	2. 790	77, 195. 0	42, 382	28. 5	.....	218	.....	.....	.....	.....	.....	.....	R.
4	11. 15 a. m.	7. 67	1, 472	26, 980. 8	2. 713	73, 199. 0	42, 329	28. 4	53	.....	.....	.....	.....	.....	.....	.....	R.
6	9. 40 a. m.	7. 84	1, 469	27, 068. 8	2. 886	78, 120. 6	42, 167	28. 3	162	.....	.....	.....	.....	.....	.....	.....	R.
7	10. 45 a. m.	8. 10	1, 471	27, 517. 6	2. 838	78, 095. 0	42, 234	28. 4	.....	67	. 0532	.....	.....	.....	.....	.....	R.
8	10. 00 a. m.	8. 35	1, 472	27, 702. 4	2. 921	80, 918. 7	42, 051	28. 3	183	.....	.....	.....	.....	.....	.....	.....	R.
9	9. 40 a. m.	8. 68	1. 474	28, 388. 8	2. 992	84, 939. 3	42, 251	28. 4	.....	200	. 0620	0	3	3	2	0	R.
10	8. 45 a. m.	8. 98	1, 475	28, 934. 5	3. 074	88, 944. 4	42, 355	28. 5	.....	104	.....	.....	.....	.....	.....	.....	R.
13	12. 00 m.	9. 33	1, 475	29, 356. 8	3. 137	92, 092. 3	42, 261	28. 4	94	.....	.....	.....	.....	.....	.....	.....	R.
14	11. 00 a m.	9. 22	1, 474	29, 700. 0	3. 044	90, 406. 8	42, 766	28. 7	.....	505	. 0688	.....	.....	.....	.....	.....	R.
15	10. 00 a. m.	9. 07	1, 474	29, 761. 6	3. 082	91, 725. 3	43, 049	28. 9	.....	283	. 0664	.....	.....	.....	.....	.....	R.
16	9. 35 a. m.	8. 80	1, 473	29, 224. 8	2. 929	85, 600. 8	42, 909	28. 8	140	.....	.....	22	23	21	22	4	R.
17	9. 50 a. m.	8. 55	1, 472	28, 864. 0	2. 882	83, 186. 1	42, 917	28. 8	.....	8	. 0604	.....	.....	.....	.....	.....	R.
18	9. 20 a. m.	8. 32	1, 471	28, 635. 2	2. 832	81, 094. 9	43, 026	28. 9	.....	109	. 0552	.....	.....	.....	.....	.....	R.
20	10. 30 a. m.	8. 13	1, 470	28, 740. 8	2. 766	79, 497. 1	43, 411	29. 2	.....	385	. 0528	.....	.....	.....	.....	.....	R.
21	8. 45 a. m.	8. 03	1, 470	28, 776. 0	2. 755	79, 279. 0	43, 593	29. 3	.....	182	. 0564	.....	.....	.....	.....	.....	R.
22	10. 00 a. m.	7. 94	1, 469	28, 476. 8	2. 710	77, 172. 1	43, 426	29. 2	167	.....	. 0524	.....	.....	.....	.....	.....	R.
23	8. 50 a. m.	7. 94	1, 469	28, 740. 8	2. 709	77, 858. 8	43, 690	29. 4	.....	264	.....	26	27	24	26	5	R.
24	8. 30 a. m.	7. 96	1, 469	28, 714. 4	2. 719	78, 074. 5	43, 635	29. 3	55	.....	.....	.....	.....	.....	.....	.....	R.
25	10. 00 a. m.	7. 99	1, 469	28, 740. 8	2. 752	79, 094. 7	43, 617	29. 3	18	.....	. 0560	.....	.....	.....	.....	.....	R.
27	11. 10 a. m.	7. 88	1, 469	28, 837. 6	2. 739	78, 986. 2	43, 876	29. 5	.....	259	. 0560	.....	.....	.....	.....	.....	R.
28	10. 15 a. m.	7. 78	1, 469	28, 679. 2	2. 720	78, 007. 4	43, 864	29. 5	12	.....	0. 0558	.....	.....	.....	.....	.....	R.
29	9. 20 a. m.	7. 72	1, 468	28, 432. 8	2. 706	76, 939. 2	43, 706	29. 4	158	.....	.....	.....	.....	.....	.....	.....	R.
30	10. 40 a. m.	7. 58	1, 468	28, 415. 2	2. 651	75, 328. 7	43, 894	29. 5	.....	188	0. 0540	24	27	28	26	5	R.
July 1	10. 00 a. m.	7. 41	1, 468	28, 512. 0	2. 584	73, 675. 0	44, 241	29. 7	.....	347	0. 0558	.....	.....	.....	.....	.....	R.
2	10. 00 a. m.	7. 22	1, 468	27, 957. 6	2. 560	71, 571. 5	43, 966	29. 6	275	.....	0. 0548	.....	.....	.....	.....	.....	R.
5	10. 50 a. m.	6. 68	1, 466	26, 910. 4	2. 481	66, 764. 7	43. 711	29. 4	255	.....	0. 0502	.....	.....	.....	.....	.....	R.
6	10. 10 a. m.	6. 57	1, 465	26, 532. 0	2. 391	63, 438. 0	43, 494	29. 2	217	.....	0. 0502	.....	.....	.....	.....	.....	R.
7	10. 10 a. m.	6. 68	1, 466	26, 646. 4	2. 447	65, 203. 8	43, 447	29. 2	47	.....	0. 0498	31	26	27	28	6	R.
8	10. 00 a. m.	6. 65	1, 466	26, 752. 0	2. 422	64, 793. 4	43, 597	29. 3	.....	150	0. 0508	76	.....	64	70	14	R.
9	9. 40 a. m.	6. 55	1, 465	26, 787. 4	2. 421	64, 840. 9	43, 780	29. 4	.....	183	0. 0524	.....	.....	.....	.....	.....	R.
11	10. 00 a. m.	6. 85	1, 468	27, 060. 0	2. 458	66, 513. 5	43, 613	29. 3	167	.....	0. 0512	.....	76	75	76	15	R.
12	12. 00 m.	6. 79	1, 468	27, 209. 6	2. 467	67, 126. 1	43, 851	29. 5	.....	238	0. 0522	.....	.....	.....	.....	.....	R.
13	9. 50 a. m.	6. 59	1, 467	27, 007. 2	2. 396	64, 709. 3	43, 941	29. 5	.....	90	0. 0480	.....	.....	.....	.....	.....	R.
14	8. 50 a. m.	6. 24	1, 465	26, 417. 6	2. 312	61, 077. 5	43, 865	29. 5	76	.....	.....	49	94	46	71	13	R.
15	9. 50 a. m.	5. 88	1, 463	25, 819. 2	2. 220	57, 318. 6	43, 793	29. 4	72	.....	0. 0454	.....	.....	.....	.....	.....	R.
16	11. 00 a. m.	5. 50	1, 463	25, 203. 1	2. 183	55, 018. 6	43, 733	29. 4	60	.....	0. 0440	.....	.....	.....	.....	.....	R.
18	9. 50 a. m.	4. 84	1, 462	24, 261. 6	2. 024	49, 105. 5	43, 757	29. 4	.....	24	.....	.....	.....	.....	.....	.....	R.

	19	10.00 a. m.	4.63	1,462	24,041.6	1.996	47,987.0	43,844	29.5	.....	87	0.0312	.....	.....	.....	.....	.....	R.
	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.0428	.....	.....	.....	.....	.....	R.
	21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	34	28	32	6	R.
	22	11.10 a. m.	5.07	1,463	24,455.2	2.169	53,043.4	43,614	29.3	230	.....	0.0440	21	24	48	31	6	R.
	23	11.15 a. m.	5.52	1,464	25,194.1	2.298	57,896.7	43,694	29.4	.....	80	0.0450	.....	.....	.....	.....	.....	R.
	25	9.00 a. m.	6.25	1,465	26,426.4	2.392	63,212.0	43,857	29.5	.....	163	.....	46	52	48	50	10	R.
	26	10.50 a. m.	6.22	1,465	26,294.4	2.367	62,238.9	43,769	29.4	88	.....	0.0512	.....	.....	.....	.....	.....	R.
	28	10.20 a. m.	5.52	1,464	25,432.0	2.200	55,950.4	43,932	29.5	.....	163	0.0454	24	35	21	27	6	R.
	29	11.20 a. m.	5.08	1,463	24,798.4	2.104	52,175.8	43,942	29.5	.....	10	0.0422	.....	.....	.....	.....	.....	R.
	30	10.00 a. m.	4.68	1,462	24,006.4	2.001	48,036.8	43,735	29.4	207	.....	0.0414	.....	.....	.....	.....	.....	R.
Aug.	1	9.15 a. m.	3.98	1,460	22,976.8	1.797	41,289.3	43,729	29.4	6	.....	0.0370	.....	.....	.....	.....	.....	R.
	2	10.15 a. m.	3.68	1,454	22,422.4	1.733	38,863.5	43.612	29.3	117	.....	0.0334	.....	.....	.....	.....	.....	R.
	4	10.00 a. m.	3.14	1,447	21,762.4	1.650	35,907.4	43,735	29.4	.....	123	0.0302	19	26	27	25	5	R.
	5	10.15 a. m.	2.94	1,447	21,364.0	1.608	34,354.7	43,626	29.3	109	.....	.....	.....	.....	.....	.....	.....	R.
	6	9.10 a. m.	2.78	1,446	21,111.2	1.609	33,967.9	43,604	29.3	22	.....	.....	.....	.....	.....	.....	.....	R.
	8	9.50 a. m.	2.59	1,446	20,715.2	1.507	31,217.8	43,483	29.2	121	.....	.....	.....	.....	.....	.....	.....	R.
	9	9.35 a. m.	2.56	1,445	20,548.0	1.560	32,054.9	43,359	29.1	124	.....	.....	.....	.....	.....	.....	.....	R.
	11	9.00 a. m.	2.57	1,446	20,688.8	1.522	31,488.4	43,486	29.2	.....	127	0.0238	22	31	25	40	9	R.
	12	9.20 a. m.	2.80	1,447	20,700.0	1.629	33,720.3	43,165	29.0	321	.....	0.0264	.....	.....	.....	.....	.....	R.
	13	8.40 a. m.	3.05	1,450	20,812.0	1.715	35,774.9	42,915	28.8	250	.....	.....	.....	.....	.....	.....	.....	R.
	15	10.30 a. m.	3.27	1,453	21,322.4	1.711	36,482.6	43,106	29.0	.....	191	.....	.....	.....	.....	.....	.....	R.
	16	9.30 a. m.	3.28	1,453	21,454.4	1.697	36,408.1	43,223	29.0	.....	117	.....	.....	.....	.....	.....	.....	R.
	18	8.50 a. m.	3.10	1,452	21,023.2	1.684	35,403.1	43,053	29.0	170	.....	.....	18	20	23	20	4	R.
	19	10.00 a. m	2.95	1,452	20,741.6	1.670	34,638.5	42,990	28.9	63	.....	0.0282	.....	.....	.....	.....	.....	R.
	20	9.40 a. m.	2.81	1,449	20,556.8	1.648	33,877.6	43,008	28.9	.....	18	0.0262	.....	.....	.....	.....	.....	R.
	22	10.30 a. m.	2.55	1,448	20,204.8	1.590	32,125.6	43,032	28.9	.....	24	0.0250	.....	.....	.....	.....	.....	R.
	23	10.45 a. m.	2.45	1,444	19,976.0	1.598	31,921.7	42,950	28.9	82	.....	0.0248	.....	.....	.....	.....	.....	R.
	26	10.45 a. m.	2.62	1,446	20,248.8	1.635	33,106.8	42,977	28.9	.....	27	0.0244	.....	.....	.....	.....	.....	R.
	27	8.40 a. m.	2.88	1,449	20,671.2	1.684	34,810.4	43,023	28.9	.....	46	0.0290	.....	.....	.....	.....	.....	R.
	29	9.20 a. m.	3.18	1,453	21,111.2	1.713	36,163.5	43,028	28.9	.....	5	0.0280	.....	.....	.....	.....	.....	R.
	31	10.50 a. m.	3.44	1,457	21,428.0	1.804	38,665.0	42,967	28.9	61	.....	.....	.....	.....	.....	.....	.....	R.
Sept.	1	9.40 a. m.	3.55	1,458	21,621.6	1.785	38,594.6	43,001	28.9	.....	34	.....	.....	.....	.....	.....	.....	R.
	2	9.00 a. m.	4.19	1,466	22,704.0	1.988	45,135.6	43,147	29.0	.....	146	.....	.....	.....	.....	.....	.....	R.
	3	10.20 a. m.	4.93	1,463	23,997.6	2.189	52,530.7	43,357	29.1	.....	210	0.0438	.....	.....	.....	.....	.....	R.
	5	11.15 a. m.	5.86	1,464	25,115.2	2.376	59,673.7	43,113	29.0	244	.....	0.0478	.....	.....	.....	.....	.....	R.
	6	9.45 a. m.	6.08	1,465	25,572.8	2.408	61,579.3	43,245	29.1	.....	132	.....	.....	.....	.....	.....	.....	R.
	7	9.00 a. m.	6.22	1,465	26,012.8	2.633	68,491.7	43,480	29.2	.....	235	.....	.....	.....	.....	.....	.....	R.
	8	10.25 a. m.	6.30	1,465	26,241.0	2.502	65,053.0	43,591	29.3	.....	111	0.0552	.....	.....	.....	.....	.....	R.
	9	9.30 a. m.	6.38	1,466	26,269.9	2.449	64,333.1	43,502	29.2	89	.....	0.0562	.....	.....	.....	.....	.....	R.
	13	9.50 a. m.	6.86	1,468	26,998.4	2.640	71,275.8	43,527	29.2	.....	25	0.0590	.....	.....	.....	.....	.....	R.
	14	9.00 a. m.	7.16	1,469	27,244.8	2.696	73,452.0	43,333	29.1	194	.....	.....	.....	.....	.....	.....	.....	R.
	15	9.10 a. m.	7.58	1,471	28,010.6	2.842	79,606.1	43,482	29.2	.....	149	.....	.....	.....	.....	.....	.....	R.
	18	11.15 a. m.	9.84	1,478	31,944.0	3.439	109,855.4	44,081	29.6	.....	599	.....	.....	.....	.....	.....	.....	R.
	20	11.15 a. m.	11.22	1,482	34,003.2	3.665	124,621.9	44,098	29.6	.....	17	.....	.....	.....	.....	.....	.....	R.
	21	10.00 a. m.	11.65	1,487	34,293.6	3.731	127,949.9	43,740	29.4	358	.....	.....	.....	.....	.....	.....	.....	R.
	22	9.45 a. m.	12.00	1,488	35,296.8	3.778	133,351.6	44,222	29.7	.....	482	.....	.....	.....	.....	.....	.....	R.
	23	9.20 a. m.	12.22	1,488	35,789.6	3.738	133,781.5	44,388	29.8	.....	166	.....	.....	.....	.....	.....	.....	R.
	24	11.35 a. m.	12.23	1,488	35,516.8	3.783	134,360.0	44,100	29.6	288	.....	.....	.....	.....	.....	.....	.....	R.
	26	9.30 a. m.	12.15	1,488	35,402.4	3.658	129,502.0	44,105	10.6	.....	5	.....	.....	.....	.....	.....	.....	R.
	27	9.30 a. m.	12.08	1.488	35,552.0	3,648	129,693.7	44,358	29.8	.....	254	.....	.....	.....	.....	.....	.....	R.
	28	9.35 a. m.	12.02	1,488	35,226.8	3.640	128,227.0	44,123	29.6	236	.....	.....	.....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT CLAYTON, IOWA—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment. Milligrams in 500 cubic centimeters. Surface.	Middle depth.	Bottom.	Mean.	Parts in 100,000.	Method.
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C. ft. pr. sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Sept. 29	10. 45 a. m.	11. 92	1, 488	35, 094. 4	3. 637	127, 638. 4	44, 139	29. 6	.....	16	.....	.....	.....	.....	.....	.....	R.
30	9. 25 a. m.	12. 26	1, 488	35, 666. 4	3. 770	134, 462. 4	44, 205	29. 7	.....	66	.....	.....	.....	.....	.....	.....	R.
Oct. 1	9. 25 a. m.	12. 40	1, 488	35, 807. 2	3. 678	131, 699. 0	44, 138	29. 0	67	.....	.....	.....	.....	.....	.....	.....	R.
3	11. 10 a. m.	13. 00	1, 488	36, 608. 0	3. 960	144, 968. 0	44, 047	29. 6	91	.....	.....	.....	.....	.....	.....	.....	R.
4	11. 10 a. m.	13. 68	1, 488	37, 620. 0	4. 042	152, 050. 0	44, 047	29. 6	0	0	.....	.....	.....	.....	.....	.....	R.
7	9. 50 a. m.	15. 30	1, 488	40, 180. 8	4. 035	164, 540. 4	44, 198	29. 7	....	151	.....	.....	.....	.....	.....	.....	R.
8	12. 45 p. m.	16. 20	1, 488	41, 272. 0	4. 211	173, 796. 3	43, 950	29. 5	248	.... .	.....	.....	.....	.....	.....	....	R.
10	10. 30 a. m.	17. 56	1, 488	44, 052. 8	4. 066	179, 118. 7	44, 707	30. 0	.....	757	.....	.....	.....	.....	.....	.....	R.
12	10. 00 a. m.	17. 25	1, 488	43, 832. 8	4. 033	176, 777. 6	44, 948	30. 2	.....	241	.....	.....	.....	.....	.....	.....	R.
13	10. 20 a. m.	16. 93	1, 488	43, 111. 2	4. 050	174, 600. 3	44, 702	30. 0	246	.....	.....	.....	.....	.....	.....	.....	R.
16	12. 45 p. m.	16. 44	1, 488	42, 319. 2	3. 989	168, 811. 7	44, 639	30. 0	63	.....	.....	.....	.....	.....	.....	.....	R.
18	10. 20 a. m.	17. 36	1, 488	43, 516. 0	3. 979	173, 150. 2	44, 467	29. 9	172	.....	.....	.....	.....	.....	.....	.....	R.
19	11. 30 a. m.	17. 63	1, 488	43, 973. 6	3. 965	174, 355. 4	44, 525	29. 9	.....	58	.....	.....	.....	.....	.....	.....	R.
21	10. 00 a. m.	17. 98	1, 488	44, 123. 2	4. 035	178, 033. 7	44, 153	29. 7	372	....	.....	.....	.....	.....	.....	.....	R.
22	9. 50 a. m.	17. 90	1, 488	44, 158. 5	4. 039	178, 355. 9	44, 308	29. 8	.... ..	155	.....	.....	.....	.....	.....	.....	R.
24	10. 05 a. m.	17. 62	1, 488	43, 815. 2	3. 925	171, 974. 4	44, 381	29. 8	.....	73	.....	.....	.....	.. ..	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT HANNIBAL, MO.

1880.																	
Nov. 12	.....	74. 02	1, 241	20, 311. 3	2. 161	43, 885. 9	51, 930	20. 5	....	.....	.....	.....	.....	.....	.....	.....	R.
13	.....	74. 08	1, 241	20, 363. 5	2. 092	42, 600. 3	51, 909	20. 5	21	.....	.....	.....	.....	.....	.....	.....	R.
15	.....	74. 63	1, 277	21, 221. 0	2. 280	48, 373. 0	52, 084	20. 5	.....	175	.....	.....	.....	.....	.....	....	R.
Dec. 13	.....	73. 10	1, 250	18. 805. 1	1. 892	35, 586. 3	51, 580	20. 3	504	.....	.....	.....	.....	.....	.....	.....	R. and M.
14																	
1881.																	
Jan. 3	.....	73. 45	1, 240	18, 841. 8	1. 571	29, 599. 6	51, 168	20 1	412	.....	.....	.....	.....	.....	.....	.....	M.
4																	
11	.....	72. 45	1, 240	17, 693. 3	1. 410	24, 937. 1	51, 259	20. 2	.....	91	.....	{ 20	31	22	26	5	M.
12												{ 27	17	13	19	4	M.
15	.....	.....	.....	.....	.....	.....	.....	.....	.. ..	.....	.....	13	19	.....	17	3	M.
18	.....	72. 70	1, 240	17, 802. 0	1. 415	29, 189. 9	51, 058	20. 1	201	.. ....	.....	.....	.....	.....	.....	.....	M.
19	.....	72. 70	1, 240	17, 959. 3	1. 405	25, 232. 0	51, 215	20. 2	.....	157	.....	.....	.....	.....	.....	.....	M.

	20		72.62	1,240	18,065.5	1.404	25,371.4	51,421	20.2		206		3	10	8	8	1	M.
	25		72.45	1,240	17,647.5	1.319	23,286.3	51,214	20.2	207								M.
	26																	
	28		72.40	1,240	17,546.5	1.283	22,496.7	51,175	20.1	39								M.
	29		72.38	1,240	17,581.5	1.283	22,548.0	51,234	20.2		59		13	13	12	13	3	M.
	31		72.28	1,240	17,493.3	1.295	22.655.2	51,270	20.2		36							M.
Feb.	2												19	17	12	16	3	M.
	3		72.37	1,240	17.523.3	1.301	22,793.7	51,188	20.1	82								M.
	4		72.37	1,240	17,595.7	1.324	23,300.1	51,261	20.2		73							M.
	5		72.35	1,210	17,458.3	1.322	23,085.7	51,148	20.1	113								M.
	7		73.22	1,266	18,658.2	1.617	30,163.5	51,269	20.2		121		81	97	103	96	19	M.
	8												97	130	166	131	26	M.
	9		75.40	1,342	21,647.5	2.029	43,916.9	51,383	20.2		114							M.
	10		76.15	1,543	22,744.0	2.436	55,391.4	51,355	20.2	28								M.
	17		74.83	1,291	20,822.0	2.015	41,937.2	51,387	20.2		32							M.
	19		74.42	1,291	20,156.1	1.863	37,557.4	51,282	20.2	105								M.
	21		74.00	1,272	19,642.5	1.752	34,399.6	51,387	20.2		105		15	19	13	17	3	M.
	23		73.70	1,267	19,146.3	1.595	30,540.9	51,100	20.1	287								M.
	24		73.58	1,267	19,220.2	1.578	30,332.1	51,385	20.2		285							M.
	25		73.50	1,267	19,176.9	1.560	29,917.1	51.440	20.3		55							M.
	26		73.42	1,263	19,079.7	1.551	29,594.6	51,443	20.3		3							M.
	28												93	98	88	94	19	M.
Mar.	1		76.15	1,543	23,117.9	2.397	55,406.7	51,728	20.4		285		51	57	66	58	12	M.
	2		76.58	1,543	23,570.7	2.565	60,472.7	51,517	20.3	211			49	52	48	50	10	M.
	3												132	70	91	92	20	M.
	5		77.70	1,544	25,083.7	2.907	72,945.3	51,267	20.2	250			48	36		40	8	M.
	7												60	66	120	78	16	M.
	8		77.40	1,544	24,391.3	2.760	67,324.2	51,044	20.1	223								M.
	9		77.10	1,544	23,839.7	2.628	62,656.7	50,964	20.1	80								M.
	10		76.67	1,544	23,287.7	2.604	60,621.0	51,094	20.1		130							M.
Apr.	4												178	221	242	216	43	M.
	7												138	168	174	162	32	M.
	8												101	130	119	120	23	M.
	9												100	124	170	132	27	M.
	12												226	255	283	255	51	M.
	29		88.20	2,535	52,498.0	5.193	272,609.3	57,065	22.5		5,971							R.
May	2		86.60	2,535	47,568.3	4.933	234,662.9	56,194	22.1		871							R.
	3												91	104	105	101	20	R.
	4		85.80	2,520	44,913.3	4.775	214,460.3	55,539	21.9		655							R.
	5												43	34		37	8	R.
	6												16	25	23	22	4	R.
	7												19	32	27	28	5	R.
	9		83.20	2,505	38,003.0	4.264	162,061.4	55,159	21.7	380								R.
	10												10	14	17	14	3	R.
	11		82.95	2,505	37,333.0	4.418	164,942.5	55,120	21.7	39								R.
	12												17	21	15	19	3	R.
	13		83.65	2,505	38,420.0	4.531	174,098.1	54,441	21.4	679								R.
	14												22	24	32	34	7	R.
	16		85.20	2,525	43,830.0	4.775	209,281.1	55,983	22.0		1,542							R.
	17												113	80	11	71	14	R.

CURRENT AND SEDIMENT OBSERVATIONS AT HANNIBAL, MO.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C. ft. per sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
May 18		86.00	2,525	46,091.3	4.874	224,659.9	56,219	22.1		236							R.
19												55	49	43	49	10	R.
23																	
24		84.90	2,520	41,766.5	4.446	185,707.6	54,669	21.5	1,550								R.
25																	
26		83.90	2,505	39,408.5	4.359	171,788.4	54,799	21.6		130							R.
27												18	28	28	26	5	R.
28												19	33	48	33	7	R.
30		81.80	1,588	34,295.5	3.990	136,842.3	54,075	21.3	724								R.
31												38	30	38	34	7	R.
June 1		81.29	1,580	33,261.0	3.720	123,740.9	53,845	21.2	230								R.
2												28	48	40	41	8	R.
3		80.66	1,574	31,985.9	3.691	118,052.2	53,562	21.1	283			36	37	47	39	8	R.
4												33	46	27	38	7	R.
6		80.15	1,575	31,221.7	3.520	109,899.8	53,604	21.1		42							R.
7		80.08	1,575	31,356.3	3.623	113,606.2	53,850	21.2		246							R.
8												64		77	71	14	R.
13		81.80	1,585	34,054.7	4.062	138,334.5	53,833	21.2	17								R.
14		82.15	1,585	34,866.5	4.219	147,090.4	54,089	21.3		256							R.
15		82.79									0.144						R.
16		83.08									0.146						R.
17		83.25									0.159						R.
18		83.33	2,595	38,931.3	4.531	176,410.6	55,759	22.0		1,670	0.124						R.
20		83.25									0.101						R.
21		83.80									0.094	236	309	190	261	49	R.
22		84.37	2,515	41,495.0	4.686	194,425.1	55,652	21.9	107		0.145						R.
23		84.40									0.156						R.
24		84.36	2,505	38,919.0	4.466	173,822.7	53,552	21.1	2,100		0.156						R.
		84.20															R.
25		83.58									0.149	139	169	236	178	36	R.
27		82.25									0.139						R.
28		82.25	1,585	33,120.5	4.188	138,701.9	52,184	20.5	1,368		0.136	166	167	333	208	44	R.
29		82.75	2,505	34,963.3	4.346	151,961,7	53,233	21.0		1,049	0.144						R.
30		82.96									0.146						R.
July 1		83.49									0.150	447	567	640	555	110	R.
2		83.69									0.148	340	476	476	442	86	R.
5		82.17									0.138						R.

	6		81.45	1,580	31,494.0	3.949	124,375.6	51,824	20.4	1,409		0.128						R.
	7		80.66									0.125						R.
	8		80.00	1,576	29,449.1	3.513	103,439.7	52,072	20.5		248	0.115						R.
	9		79.42									0.103						R.
	11		79.10	1,570	27,684.0	3.250	89,971.3	51,721	20.4	351		0.103						R.
	12		79.95									0.120		133	187	151	32	R.
	13		80.79									0.130	556	675	697	651	129	R.
	14		81.54									0.137	326	425	469	411	81	R.
	15		82.75	1,675	35,183.3	4.348	152,987.2	53,453	21.0		1,732	0.148	200	320	285	281	54	R.
	16		83.80									0.148	265	317	199	275	52	R.
	18		85.65	2,520	41,920.3	5.121	214,679.3	52,925	20.8	528								R.
	19																	
	20		86.70	2,525	45,320.0	5.170	234,286.4	53,679	20.7		754							R.
	21																	
	26		80.76	1,580	30,661,5	3.792	116,272.4	52,102	20.5	1,577		0.111						R.
	27		80.10	1,576	29,268.7	3.596	105,262.8	51,734	20.4	368		0.098						R.
	28												51	62	80	64	13	R.
	29		79.58	1,573	28,465.9	3.500	99,621.7	51,751	20.4		17	0.090						R.
	30		79.35									0.084						R.
Aug.	1		78.98									0.088						R.
	2		78.65	1,565	27,048.5	3.323	89,874.4	51,785	20.4		34	0.106						R.
	3		78.35	1,562	26,524.5	3.211	85,180.4	51,724	20.4	61		0.076						R.
	4												33	43	54	43	9	R.
	5		77.52	1,556	25,664.1	2.940	75,457.8	52,160	20.5		336	0.066						R.
	6		77.10	1,545	26,127.0	2.861	74,739.6	53,342	21.0		1,182	0.056						R.
	8		76.44	1,530	25,419.3	2.566	65,225.9	53,577	21.9		235							R.
	9		76.05	1,515	24,923.5	2.477	61,729.6	53,675	21.1		98							R.
	11		75.55									0.038						R.
	12		75.37	1,504	24,603.4	2.261	55,637.8	54,487	21.4		812	0.041						R.
	13		75.23	1,494	24,788.0	2.187	54,219.0	54,777	21.6		290	0.028						R.
	15		75.00	1,443	24,402.8	2.106	51,401.4	54,736	21.6	41		0.028						R.
	16		74.92	1,443	24,159.9	2.072	50,050.6	54,521	21.5	215		0.024						R.
	17		74.83	1,441	24,132.7	2.064	49,812.4	54,710	21.5		189	0.031						R.
	19		74.92	1,443	24,211.5	2.052	49,681.5	54,820	21.6		110	0.031						R.
	20		75.00	1,445	24,372.1	2.075	50,561.5	54,705	21.5	115		0.026						R.
	23		75.00	1,443	24,290.9	2.067	50,209.5	54,623	21.5	82		0.023						R.
	24		74.98	1,443	24,196.0	2.037	49,284.9	54,559	21.5	64		0.028						R.
	27		74.83	1,441	24,131.7	2.040	49,217.5	54,709	21.5		150	0.026						R.
	29		74.67	1,438	23,861.5	1.968	46,952.3	54,669	21.5	40		0.028						R.
Sept.	1		74.58	1,437	23,669.2	1.968	46,578.5	54,607	21.5	62		0.023						R.
	2		74.64	1,438	23,924.0	1.955	46,774.4	54,775	21.6	168								R.
	7		75.15	1,444	24,390.8	2.138	52,159.3	54,507	21.5	268		0.024						R.
	8		75.44	1,504	24,703.5	2.315	57,179.9	54,381	21.4	126		0.034						R.
	9		75.78	1,510	25,247.5	2.305	58,200.4	54,410	21.4		29	0.026						R.
	12		76.60	1,530	27,022.5	2.640	71,338.3	54,935	21.6		525	0.051						R.
	13		76.82	1,538	27,316.1	2.761	75,432.4	54,890	21.6	45		0.073						R.
	14		77.00	1,544	27,791.8	2.766	76,879.2	55,088	21.7		198	0.076						R.
	16		77.34	1,551	28,404.7	2.829	80,371.4	55,174	21.7		86							R.
	17		77.44	1,556	28,629.9	2.913	72,088.6	55,253	21.7		79	0.077						R.
	19		77.79	1,564	29,300.6	2.899	84,935.1	55 392	21.8		139	0.078						R.
	20		78.00	1,565	29,553.7	2.969	87,763.6	55,319	21.8	73		0.078						R.
	22		78.42	1,566	30,277.3	3.170	96,083.0	55,379	21.8		60	0.083						R.

CURRENT AND SEDIMENT OBSERVATIONS AT HANNIBAL, MO.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment. Milligrams in 500 cubic centimeters. Surface.	Middle depth.	Bottom	Mean.	Parts in 100,000.	Method.
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C ft. per sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Sept. 27	.....	80.00	.....	.....	.....	.....	.....	.....	.....	.....	0.095	.....	.....	.....	.....	.....	R.
28	.....	80.30	1,578	33,744.4	3.861	130,400.3	55,895	22.0	.....	516	0.125	.....	.....	.....	.....	.....	R.
Oct. 7	.....	81.53	.....	.....	.....	.....	.....	.....	.....	.....	0.090	.....	.....	.....	.....	.....	R.
6	.....	84.08	.....	.....	.....	.....	.....	.....	.....	.....	0.108	.....	.....	.....	.....	.....	R.
10	.....	84.50	.....	.....	.....	.....	.....	.....	.....	.....	0.109	.....	.....	.....	.....	.....	R.
12	.....	84.67	.....	.....	.....	.....	.....	.....	.....	.....	0.145	.....	.....	.....	.....	.....	R.

CURRENT AND SEDIMENT OBSERVATIONS AT GRAFTON, ILL.

Nov. 13	12.00 m ...	14.98	.....	30,275.0	1.341	46,652.06	76,698	31.6	.....	.....	.....	33	80	82	69	13	R.
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	31	34	76	44	9	R.
1881.																	
Jan. 6	12.00 m ...	14.56	.....	22,387.5	1.388	31,066.16	69,384	28.6	7,314	.....	.....	.....	.....	.....	.....	.....	M.
7	12.00 m ...	14.51	.....	21,950.0	1.273	27,935.48	69,013	28.4	371	.....	.....	.....	.....	.....	.....	.....	.....
8	12.00 m ...	14.47	.....	21,787.5	1.223	26,644.92	68,901	28.4	112	.....	.....	.....	.....	.....	.....	.....	.....
11	.....	14.08	.....	20,952.5	1.187	24,868.91	68,536	28.2	365	.....	.....	.....	.....	.....	.....	.....	.....
15	.....	13.82	.....	20,037.5	1.251	25,062.63	67,938	28.0	598	.....	.....	.....	.....	.....	.....	.....	.....
17	.....	13.89	.....	20,375.0	1.327	27,046.72	68,185	28.1	.....	157	.....	.....	.....	.....	.....	.....	.....
19	.....	13.93	.....	20,200.0	1.357	27,412.07	67,956	28.0	229	.....	.....	.....	.....	.....	.....	.....	.....
20	.....	13.94	.....	20,312.5	1.355	27,520.19	68,055	28.0	.....	99	.....	.....	.....	.....	.....	.....	.....
24	.....	13.87	.....	20,000.5	1.332	26,649.58	67,836	27.9	219	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	13.86	.....	20,062.5	1.340	26,882.68	67,912	27.9	.....	76	.....	.....	.....	.....	.....	.....	.....
26	.....	13.84	.....	20,025.0	1.343	26,895.97	67,901	27.9	11	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26	15	39	24	4	.....
Feb. 2	.....	14.08	.....	20,662.5	1.354	27,985.38	68,215	28.1	.....	314	.....	.....	.....	.....	.....	.....	.....
3	.....	14.06	.....	20,562.5	1.352	27,805.00	68,166	28.1	73	.....	.....	23	43	32	35	7	.....
17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	217	160	137	193	41	M.
28	11.44 a. m.	18.61	2,380	41,387.9	2.342	96,917.00	80,502	33.1	.....	12,336	.....	.....	.....	.....	.....	.....	F. and I.C.
Mar. 1	8.40 a. m.	19.57	2,380	42,375.0	2.304	97,637.2	79,198	32.6	1,304	.....	.....	362	383	374	376	75	F.
2	8.39 a. m.	20.39	2,380	43,732.5	2.643	115,588.6	78,604	32.3	594	.....	.....	258	300	286	286	56	F.
5	.....	19.70	2,380	43,905.4	2.379	104,460.7	80,419	33.1	.....	1,815	.....	.....	.....	.....	.....	.....	F.
7	10.10 a. m.	20.09	2,380	43,337.5	2.583	111,951.8	78,923	32.5	1,496	.....	.....	.....	.....	.....	.....	.....	F.
8	9.16 a. m.	20.08	2,380	42,632.3	2.879	122,736.8	77,242	31.8	681	.....	.....	.....	.....	.....	.....	.....	F.
9	8.11 a. m.	20.02	2,380	42,992.5	2.706	116,105.0	78,751	32.4	.....	509	.....	161	194	106	164	31	F.

	10	8.50 a. m.	20.11	2,380	42,855.0	2.824	121,017.1	78,592	32.3	352						
	12	8.49 a. m.	21.33	2,385	43,912.5	3.225	141,612.3	76,744	31.6	1,848						
	14	8.29 a. m.	23.03	2,390	47,702.5	3.361	160,311.1	76,476	31.5	268			343	356	354	352	70	
	15	8.32 a. m.	23.32	2,390	49,005.0	3.332	163,293.7	77,086	31.7		610		271	262	201	249	49	
	16	2.08 p. m.	23.66	2,392	49,237.5	3.537	174,129.1	76,506	31.5	580			239	248		245	49	
	17	8.18 a. m.	23.98	2,392	50,250.0	3.441	172,892.3	76,754	31.6		248		207	228	270	244	49	
	18	8.12 a. m.	24.00	2,392	50,910.0	3.344	17 , 223.8	77,366	31.8		612		222	272	246	253	49	
	21	8.59 a. m.	24.67	2,392	51,572.5	3.357	173,147.3	77,861	32.0		495		180	191	200	191	38	
	22	8.15 a. m.	23.69	2,391	49,200.0	3.409	167,701.3	76,397	31.4	1,464			142	161	124	147	28	
	23	8.29 a. m.	23.41	2,390	48,870.0	3.365	164,426.2	76,736	31.6		339							
	24	8.43 a. m.	23.32	2,390	47,865.0	3.318	158,811.5	75,946	31.3	790								
	25	8.50 a. m.	23.36	2,390	47,207.5	3.251	153,466.5	75,192	30.9	754								
	28	8.16 a. m.	24.07	2,391	50,787.8	3.510	178,253.9	77,075	31.7		1,883							
	30	9.13 a. m.	25.41	2,395	54,587.9	3.967	216,556.5	77,669	30.0		594							
Apr.	2	12.14 p. m.	26.86	3,395	56,669.6	3.883	220,037.7	76,279	31.4	1,390								
	4	12.14 p. m.	27.32	2,395	57,506.7	4.063	233,625.0	76,014	31.3	265								F.
	5	12.40 p. m.	27.49	2,395	60,281.5	3.959	238,670.5	78,382	32.3		2,368							F. with P. & B. L.
	6	3.35 p. m.	27.52	2,397	61,212.8	4.019	246,033.3	79,242	32.6		860							
	8	1.05 p. m.	28.36	2,398	62,850.3	3.994	251,018.0	78,866	32.5	376								F.
	9	9.14 a. m.	28.71	2,399	61,900.1	4.327	267,855.4	77,077	31.7	1,789								Mid. depth plant.
	11	9.02 a. m.	29.21	2,403	64,087.8	3.995	256,044.0	78,064	32.1		987	.0702	184	66	117	108	24	
	12	12.23 p. m.	29.48	2,405	65,825.2	4.378	288,156.4	79,152	32.6		1,088		220	194	184	198	40	F.
	13											.0691	309	167	235	220	47	F.
	14	11.19 a. m.	29.80	2,410	67,812.8	4.039	273,925.8	80,370	33.1		1,218	.0668	220		251	236	47	
	16	8.55 a. m.	29.97	2,416	63,050.4	4.254	268,204.0	75,198	30.9	5,172		.0651	173	166	302	202	43	
	18	8.42 a. m.	29.87	2,416	63,237.8	4.379	276,926.7	75,627	31.1		429	.0673	123	112	108	114	23	
	19	8.56 a. m.	29.77	2,416	63,031.6	4.214	265,640.1	75,663	31.1		36	.0711						
	20	8.53 a. m.	29.70	2,416	64,462.8	4.297	277,015.2	77,263	31.8		1,600	.0723	128	162	146	150	29	
	21	8.45 a. m.	29.88	2,416	63,525.0	4.417	280,605.9	75,891	31.2	1,373		.0644						
	22	8.24 a. m.	30.29	2,416	63,657.0	4.299	273,631.9	75,033	30.9	858		.0733						
	23	8.37 a. m.	30.83	2,416	63,800.0	4.410	281,349.3	73,872	30.4	1,161		.0718						
	25	12.23 p. m.	32.17	2,416	67,545.0	4.594	310,309.4	74.380	30.6		508	.0661	90	101	134	107	22	
	26													14	12	10	2	
	27	3.02 p. m.	33.19	2,416	73,620.0	4.584	337,486.5	77,991	32.1		3,611		85	85	100	89	18	
	28	11.03 a. m.	33.48	2,416	73,815.0	4.412	325,638.3	77,486	31.9	505		.0683						
	29	8.31 a. m.	33.68	2,416	73,920.0	4.471	330,482.4	77,108	31.7	378		.0661	44	57	68	57	11	
	30											.0627	40	62	55	55	10	
May	2											.0628	58	52	42	51	10	
	3	8.53 a. m.	34.02	2,416	73,435.0	4.237	311,132.3	75,802	31.2	1,306		.0593						
	4	8.54 a. m.	34.13	2,416	73,725.0	4.005	295,285.4	75,826	31.2		24							
	5	9.39 a. m.	34.22	2,416	74,010.0	3.937	291,364.8	75,894	31.2		68	.0443	75	88	56	77	15	
	6	10.07 a. m.	34.16	2,416	73,695.0	3.859	284,405.6	75,725	31.2	169		.0444						
	7	8.16 a. m.	33.79	2,416	72,832.5	3.762	274,013.7	75,757	31.2		32	.0487						
	9	8.37 a. m.	31.94	2,416	68,192.5	4,214	287,378.0	75,587	31.1	170		.0629	69	79	69	74	14	
	10	8.15 a. m.	30.86	2,416	66,697.5	4.316	287,888.9	76 701	32.0		1,114	.0628	69	72		71	14	
	11	8.09 a. m.	29.96	2,416	64,485	4.154	267,873.9	76,662	32.0	39		.0628	45	78	197	100	22	

Mid-depth, base-line.....
Mid depth base-line.....

CURRENT AND SEDIMENT OBSERVATIONS AT GRAFTON, ILL.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C ft. per sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
May 12	8.20 a. m.	29.18	2,431	61,730	4.119	254,273.4	75,798	31.2	864	.....	.0621	191	131	221	169	36	
13	7.04 a. m.	28.85	2,431	61,495	3.892	239,356.8	76,365	31.4	.....	567	.0415	187	273	196	232	44	
14	8.26 a. m.	28.70	2,428	60,650	3.926	238,118.9	75,884	31.2	481	.....	.....	107	108	107	107	21	
16	8.47 a. m.	28.42	2,431	60,090	3,907	234,768.9	76,004	31.3	.....	120	.0617	.....	.....	.....	.....	.....	
17	9.44 a. m.	28.45	2,428	61,775	4.046	249,969.5	77,616	31.9	.....	1,612	.0628	.....	.....	.....	.....	.....	
18	3.52 p. m.	28.57	Above mou th of Illino is River.			250,228.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
19	4.07 p. m.	28.77	2,428	61,765	4.039	249,491.9	76,829	32.0	787	.....	.....	.....	.....	.....	.....	.....	
20	8.15 a. m.	28.88	2,431	60,860	4.117	250,547.8	75,657	31.1	1,172	.....	.0664	.....	.....	.....	.....	.....	
21	8.08 a. m.	28.90	2,434	61,120	4.133	250,220.9	75,868	31.2	.....	211	.0701	.....	.....	.....	.....	.....	
23	8.05 a. m.	28.67	2,427	60,865	4.225	257,167.4	76,172	31.3	.....	304	.0677	.....	.....	.....	.....	.....	
24	8.12 a. m.	28.57	2,427	61,495	4.084	251,115.1	77,045	31.7	.....	873	.0642	40	43	91	54	12	
25	8.14 a. m.	28.35	2,427	60,780	3.942	239,597.1	76,864	31.6	181	.....	.0617	33	54	80	55	11	
26	7.48 a. m.	28.04	2,425	60,115	3.897	234,255.5	76,951	31.7	.....	87	.0586	61	57	60	56	12	
27	7.58 a. m.	27.57	2,422	59,440	3.719	221,050.4	77,415	31.4	.....	464	.0544	34	59	61	53	10	
28	7.59 a. m.	26.96	2,423	57,215	3.593	205,585.8	76,667	31.6	748	.....	.0534	42	48	58	49	10	
30	7.51 a. m.	25.63	2,419	54,350	3.482	189,243.1	76,922	31.7	.....	355	.....	.....	114	64	73	12	
31	8.11 a. m.	25.08	2,419	53,790	3.255	175,112.3	77,792	32.0	.....	770	.0566	58	47	54	52	11	
June 1	8.45 a. m.	24.60	2,419	52,580	3.269	171,899.8	77,743	32.0	49	.....	.0552	.....	.....	.....	.....	.....	
2	8.13 a. m.	24.19	2,416	51,590	3.265	168,420.5	77,743	32.0	0	0	.....	.....	.....	.....	.....	.....	
3	8.01 a. m.	23.88	2,416	50,735	3.102	157,373.4	77,637	31.9	106	.....	.0529	58	72	55	64	12	
4	8.09 a. m.	23.58	2,416	49,940	3.054	152,521.2	77,567	31.9	70	.....	.0500	51	70	59	63	12	
6	8.07 a. m.	23.16	2,413	48,610	2.846	138,322.4	77,251	31.8	316	.....	.0461	63	69	99	75	15	
7	1.50 p. m.	22.80	Above mo uth of Illino is River.			134,788.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
8	1.51 p. m.	22.72	2,419	47,937.5	2.848	136,527.3	77,642	32.4	.....	391	.0454	.....	.....	.....	.....	.....	
9	7.47 a. m.	22.72	2,419	47,943.7	2.856	136,948.9	77,648	32.0	.....	6	.0454	74	89	89	85	17	
10	7.55 a. m.	23.05	2,416	48,156.3	2.985	143,746.6	77,062	31.7	586	.....	.0491	73	84	92	83	17	
11	7.48 a. m.	23.29	2,416	49,250.0	3.004	147,938.5	77,576	31.9	.....	514	.....	244	263	167	234	45	
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	255	286	190	254	49	
13	7.59 a. m.	24.01	2,421	50,900.0	3.105	159,048.5	77,485	31.9	91	.....	.0531	.....	.....	.....	.....	.....	
14	8.32 a. m.	24.39	2,422	51,956.3	3.185	165,480.9	77,621	31.9	.....	136	.0532	.....	.....	.....	.....	.....	
15	7.53 a. m.	24.57	2,422	52,043.7	3.185	165,738.3	77,273	31.8	348	.....	.0550	.....	.....	.....	.....	.....	
16	7.47 a. m.	24.87	2,422	52,540.0	3.389	178,064.7	77,042	31.7	231	.....	.0564	.....	.....	.....	.....	.....	
17	8.24 a. m.	25.29	2,425	52,635.0	3.542	186,419.4	76,119	31.3	923	.....	.0585	310	410	451	395	78	
18	8.00 a. m.	25.57	2,427	53,947.5	3.583	193,282.3	76,753	32.0	.....	634	.0601	417	385	416	401	81	
20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	329	.....	348	339	68	
21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	222	226	235	227	46	
22	8.12 a. m.	26.79	2,427	55,515.0	3.885	215,690.1	75,359	31.0	1,394	.....	.0697	252	261	265	285	59	

23	7.45 a. m.	27.10	2,431	56,855.0	3.753	213,360.0	75,946	31.3	.....	587	.0641	390	327	381	356	73		
24	7.37 a. m.	27.37	2,431	58,555.0	3.815	223,383.4	76,990	31.7	.....	1,044	.0681	330	484	518	454	89		
25	7.55 a. m.	27.47	2,431	57,215.0	3.839	219,647.6	75,407	31.0	1,583	.....	.0657	.....	.....	.....	.....	.....		
27	8.15 a. m.	26.96	2,427	57,850.0	3.692	213,597.0	77,280	31.8	.....	1,873	.0652	.....	.....	.....	.....	.....		
28	8.09 a. m.	26.48	2,427	54,787.5	3.560	195,042.5	75,382	31.0	1,898	.....	.0616	153	165	172	164	33		
29	7.51 a. m.	26.05	2,425	54,200.0	3.493	189,329.9	75,837	31.2	455	.....	.0597	176	184	226	193	39		
30	7.56 a. m.	25.89	2,425	53,175.0	3.541	188,271.3	75,200	30.9	637	.....	.0594	190	215	215	209	41		
July 1	8.31 a. m.	26.00	2,427	54,200.0	3.609	195,582.9	75,958	31.3	.....	758	.0567	520	.....	562	541	108		
2	7.42 a. m.	26.30	2,427	54,381.3	3.689	200,626.7	75,411	31.0	547	.....	.0594	424	379	439	405	83	Mid-depth.	
4	8.33 a. m.	26.80	2,427	54,756.3	3.638	199,199.8	74,572	30.7	839	.....	.....	.....	...	.....	.....	.....	Base line.	
5	7.55 a. m.	26.60	2,427	54,900.0	3.580	196,512.1	75,201	30.9	....	629	.0597	235	302	308	287	56	F.	
6	9.00 a. m.	25.97	2,427	53,125.0	3.459	183,771.1	74,955	30.9	246	.....	.0595	213	245	219	231	45		R.. Base line..R.
7	8.34 a. m.	25.36	2,425	51,700.0	3.197	165,301.6	75,010	30.9	... ..	55	.0536	197	213	263	222	45		
8	8.24 a. m.	24.48	2,422	49,537.5	3.025	149,850.2	74,980	30.9	30	.....	.0497	134	273	202	221	41		
9	9.19 a. m.	23.49	2,419	46,312.5	3.050	141,254.8	74,150	30.5	830	.....	.0485	124	180	172	164	32		
11	8.18 a. m.	21.93	2,416	43,806.3	2.675	117,175.7	75,414	30.6	.....	1,264	.0367	94	17	136	66	17		
12	8.05 a. m.	21.45	2,411	41,631.3	2.674	111,340.5	74,398	30.6	1,016	.....	.0432	84	116	112	107	21		
13	8.47 a. m.	21.54	2,410	41,332.5	2.687	111,081.1	73,882	30.4	516	.....	.0426	142	143	61	124	23		
14	9.39 a. m.	22.66	2,419	44,787.5	2.910	130,343.4	74,632	30.7	.....	750	.....	488	493	452	482	96		
15	8.25 a. m.	23.39	2,419	45,806.3	3.096	141,826.7	73,885	30.4	747	....	.0525	.....	.....	.....	.....	.....		
16	8.11 a. m.	24.27	2,421	48,137.5	3.192	153,676.4	74,086	30.5	.....	201	.0514	421	405	415	412	83	F.	
18	8.59 a. m.	25.62	2,431	51,006.3	3.437	175,284.5	73,679	30.3	407	.....	.0605	274	261	323	280	57	Mid-depth. Base line.	
19	8.45 a. m.	26.06	2,431	52,187.5	3.602	187,963.5	73,791	30.4	.....	112	.0636	187	207	178	195	38	R.	
20	8.19 a. m.	26.54	2,428	52,912.5	3.797	200,905.7	73,350	30.2	441	.... .	.0634	105	110	115	110	22	Base line.	
21	8.57 a. m.	26.95	2,427	54,610.0	3.810	208,061.7	74,042	30.5	.....	702	.0668	85	84	133	97	20	Do.	
22	8.23 a. m.	27.36	2,427	55,085.0	4.162	229,284.6	73,532	30.3	520	.....	.0685	88	79	52	75	15	Do.	
23	8.26 a. m.	27.52	2,427	57,065.0	3.968	226,416.4	75,124	30.9	.....	1,592	.0691	98	104	112	105	21	Do.	
25	8.49 a. m.	27.05	2,427	57,030.0	3.844	219,202.4	76,230	31.4	.....	1,106	.0669	.....	.....	.....	.....	.....	R.	
26	8.11 a. m.	26.13	2,422	54,580.0	3.761	205,291.0	76,011	31.3	219	.....	.0581	.....	.....	.....	.....	.....	F.	
27	8.30 a. m.	24.55	2,422	51,230.0	3.177	162,735.6	76,489	31.5	.....	478	.586	67	111	96	96	18	R.	
28	8.29 a. m.	23.09	2,413	48,768.7	2.856	139,300.9	77,568	31.9	.....	1,079	.539	71	83	.....	59	10		
29	8.18 a. m.	22.07	2,410	45,862.5	2.698	123,751.4	77,122	31.7	446	.....	.0551	59	95	102	88	17		
30	8.16 a. m.	21.49	2,407	44,218.7	2.592	114,635.8	76,875	31.6	247	.....	.0529	83	77	75	78	16		
Aug. 1	8.36 a. m.	20.91	2,407	43,018.7	2.516	108,240.5	77,071	31.7	.....	196	.0452	78	134	137	121	23		
2	1.18 p. m.	20.62	.....	.....	.....	106,636.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		
3	2.40 p. m.	20.32	2,407	41,425.0	2.413	99,963.1	76,897	31.6	174	.....	.0419	.....	.....	.....	.....	.....		
4	8.23 a. m.	20.06	2,404	40,725.0	2.344	95,477.7	76,823	31.6	74	.....	.0361	.....	129	83	114	14		
5	8.32 a. m.	19.70	2,404	39,825.0	2.335	92,978.1	76,788	31.6	35	.....	.0333	.....	71	73	72	14		
6	8.24 a. m.	19.28	2,404	38,968.7	2.196	85,577.6	76,942	31.7	....	154	.0329	.....	.....	.....	.....	.....		
8	8.25 a. m.	18.42	2,395	36,287.5	1.972	71,546.7	76,325	31.4	617	.....	.....	.....	.....	.....	.....	.....		
9	8.30 a. m.	18.04	2,392	36,062.5	1.966	70,904.2	77,006	31.7	.....	681	.0252	...	.....	...	.....	.....		
10	8.19 a. m.	17.69	2,382	34,831.3	1.864	64,910.1	76,610	31.5	396	.....	.0231	51	54	57	54	11		
11	8.09 a. m.	17.37	2,392	33,637.5	1.775	50,718.2	76,180	31.3	430	.....	.0212	29	16	50	28	6		
12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	38	48	41	9		
15	8.47 a. m.	16.42	2,392	31,043.7	1.604	49,790.3	75,858	31.2	322	.....	.0227	27	47	50	43	8		
16	8.27 a. m.	16.28	2,392	31,075.0	1.600	49,732.9	76,225	31.4	.....	367	.0278	.....	.....	.....	.....	.....		
17	8.13 a. m.	16.17	2,391	30,656.3	1.622	49,719.9	76,069	31.3	156	.....	.0149	.....	.....	.....	.....	.....		
19	.....	16.00	2,391	31,368.7	1.694	53,142.6	77,188	31.8	.....	1,119	.....	.....	.....	.....	.....	.....		
20	.....	16.00	2,391	31,637.5	1.649	52,168.9	77,454	31.9	.....	266	.0177	.....	.....	.....	.....	.....		
22	.....	16.04	2,391	31,281.3	1.646	51,500.0	77.002	31.7	452	.....	.....	36	54	73	72	11		
23	.....	16.08	2,391	31,475.0	1.622	51,052.9	77,101	31.7	.....	99	.....	.....	.....	.....	.....	.....		

CURRENT AND SEDIMENT OBSERVATIONS AT GRAFTON, ILL.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. pr. sec.*	*C. ft. pr. sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Aug. 24		16.07	2,391	31,462.5	1.611	50,673.8	77,112	31.7		11	.0171						R.
25		16.01	2,390	31,856.2	1.638	52,186.8	77,649	32.0		537							
26		15.93	2,390	31,281.3	1.599	50.009.1	77,265	31.8	384		.0176						
27		15.87	2,390	30,931.3	1.583	48,958.3	77,058	31.7	207		.0210						
29		15.79	2,390	30,388.7	1.494	45,423.0	76,707	31.6	351								
30		15.66	2,390	30,212.5	1.562	47,201.2	76,840	31.6		133			57	49	54	11	
31		15.59	2,390	30,243.7	1.511	45,809.5	77,038	31.7		198							
Sept. 1		15.55	2,390	30,062.5	1.543	46,447.4	76,952	31.7	86		.0200						
2		15.53	2,390	29,850.0	1.528	45,616.0	76,787	31.6	165		.0198						
3		15.57	2,390	30,075.0	1.536	46,192.8	76,917	31.7		130	.0229						
5		15.59	2,390	30,300.0	1.560	47,281.1	77,094	31.7		177	.0272						
6		15.72	2,390	31,068.7	1.575	48,942.7	77,552	31.9		458	.0247						
7		15.77	2,390	31,012.5	1.611	49,975.1	77,376	31.8	176		.0217						
8		15.95	2,390	31,400.0	1.655	51,966.2	77,333	31.8	43		.0220						
9		16.16	2,390	32,175.0	1.676	53,958.9	77,606	31.9		273							
10		16.41	2,390	32,300.0	1.750	56,538.4	77,133	31.7	473								
12		17.08	2,391	34,200.0	1.906	65,180.1	77,432	31.9		299	.0245						
13		17.33	2,392	34,526.3	1.932	66,698.7	77,160	31.8	272		.0281						
14		17.53	2,392	34,931.3	1.985	69,337.1	77,087	31.7	73		.0281						
15		17.72	2.392	35,062.5	2.015	70,658.7	76,764	31.6	323		.0271						
16		17.84	2,393	34,956.3	2.040	71.299.5	76,371	31.4	393		.0275						
17		18.02	2,393	35,906.3	2.139	76,804.3	76,894	31 6		523	.0271						
19		18.32	2,396	36,200.0	2.147	77,717.3	76,470	31.5	424		.0285						
20		18.56	2,397	37,087.5	2.203	8i,711.1	76,783	31.6		313	.0260						
21		18.71	2,397	37,687.5	2.235	84,247.1	77,023	31.7		240	.3307						
22		18.90	2,398	37,900.0	2.233	84,628.7	76,781	31.6	242		.0315						
23		19.09	2,399	38,400.0	2.353	90,344.0	76,825	31.6		44	.0327						
24		19.28	2,400	38,775.0	2.339	90,683.9	76,744	31.6	81		.0331						
26		19.91	2,402	39,768.7	2.466	98,058.2	76,226	31.4	518		.0308						
27		20.28	2,404	41,681.3	2.523	105,171.1	77,249	31.8		1,023	.0470						
28		20.55	2,403	41,406.3	2.619	108,425.1	77,326	31.8		77							
29		20.75	2,405	41,987.5	2.615	109,778.3	77,426	31 9		100							
Oct. 1		22.21	2,410	47,456.3	2.960	140,479.7	79,378	32.7		1,952							Plant.
4		25.34	2,418	56,125.0	3.490	195,896.9	79,491	32.7		113							

1880.																	
Oct. 14	.....	24.4	1,364	31,777	3.35	106,620	89,200	27.0	.....	.....	.....	.....	.....	.....	.....	.....	R. and F.
18	.....	23.4	1,346	30,026	3.17	95,338	88,804	26.9	396	.....	.....	.....	.....	.....	.....	.....	R. and F.
19	.....	23.2	1,328	30,529	3.12	95,221	89,574	27.1	.....	770	.....	.....	.....	.....	.....	.....	R. and F.
Nov. 2	.....	22.7	1,349	30,474	3.07	93,500	90,185	27.3	.....	615	.....	.....	.....	.....	.....	.....	F.
3	.....	22.6	1,361	31,445	3.04	95,467	91,295	27.7	.....	1,106	.....	.....	.....	.....	.....	.....	F.
5	.....	22.6	1,374	31,756	2.99	94,862	91,606	27.8	.....	311	.....	.....	.....	.....	.....	.....	F.
8	.....	22.4	1,360	29,783	2.99	88,876	89,906	27.2	1,700	.....	.....	.....	.....	.....	.....	.....	F.
10	.....	22.6	1,364	30,959	3.11	96,376	90,810	27.5	.....	904	.....	.....	.....	.....	.....	.....	F.
11	.....	22.7	1,373	31,719	3.21	102,365	91,433	27.7	.....	623	.....	.....	.....	.....	.....	.....	F.
12	.....	22.6	1,297	29,434	3.31	97,928	89,281	27.1	2,152	.....	.....	.....	.....	.....	.....	.....	F.
13	.....	22.6	1,260	30,332	3.17	96,400	90,179	27.3	.....	898	.....	.....	.....	.....	.....	.....	F.
26	.....	18.83	.....	.....	.....	.....	.....	.....	.....	.....	0.0365	.....	.....	.....	.....	.....	
27	.....	18.35	.....	.....	.....	.....	.....	.....	.....	.....	0.0372	.....	.....	.....	.....	.....	
29	.....	17.85	.....	.....	.....	.....	.....	.....	.....	.....	0.0293	.....	.....	.....	.....	.....	
30	.....	17.84	.....	.....	.....	.....	.....	.....	.....	.....	0.0394	.....	.....	.....	.....	.....	
Dec. 1	.....	18.41	.....	.....	.....	.....	.....	.....	.....	.....	0.0383	.....	.....	.....	.....	.....	
2	.....	18.63	.....	.....	.....	.....	.....	.....	.....	.....	0.0264	.....	.....	.....	.....	.....	
3	.....	18.90	.....	.....	.....	.....	.....	.....	.....	.....	0.0524	.....	.....	.....	.....	.....	
4	.....	19.14	.....	.....	.....	.....	.....	.....	.....	.....	0.0324	.....	.....	.....	.....	.....	
7	.....	19.55	.....	.....	.....	.....	.....	.....	.....	.....	0.0471	.....	.....	.....	.....	.....	
8	.....	19.26	.....	.....	.....	.....	.....	.....	.....	.....	0.0423	.....	.....	.....	.....	.....	
9	.....	19.15	.....	.....	.....	.....	.....	.....	.....	.....	0.0361	.....	.....	.....	.....	.....	
10	.....	18.96	.....	.....	.....	.....	.....	.....	.....	.....	0.0422	.....	.....	.....	.....	.....	
11	.....	19.22	.....	.....	.....	.....	.....	.....	.....	.....	0.0359	.....	.....	.....	.....	.....	
12	.....	19.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
13	.....	19.50	.....	.....	.....	.....	.....	.....	.....	.....	0.0415	.....	.....	.....	.....	.....	
14	.....	19.87	.....	.....	.....	.....	.....	.....	.....	.....	0.0448	.....	.....	.....	.....	.....	
15	.....	20.33	.....	.....	.....	.....	.....	.....	.....	.....	0.0413	.....	.....	.....	.....	.....	
16	.....	20.60	.....	.....	.....	.....	.....	.....	.....	.....	0.0483	.....	.....	.....	.....	.....	
17	.....	20.89	.....	.....	.....	.....	.....	.....	.....	.....	0.0565	.....	.....	.....	.....	.....	
18	.....	21.16	.....	.....	.....	.....	.....	.....	.....	.....	0.0640	.....	.....	.....	.....	.....	
20	.....	20.96	.....	.....	.....	.....	.....	.....	.....	.....	0.0451	.....	.....	.....	.....	.....	
21	.....	20.60	.....	.....	.....	.....	.....	.....	.....	.....	0.0372	.....	.....	.....	.....	.....	
22	.....	20.47	.....	.....	.....	.....	.....	.....	.....	.....	0.0366	.....	.....	.....	.....	.....	
23	.....	20.30	.....	.....	.....	.....	.....	.....	.....	.....	0.0500	.....	.....	.....	.....	.....	
24	.....	20.20	.....	.....	.....	.....	.....	.....	.....	.....	0.0570	.....	.....	.....	.....	.....	
27	.....	20.24	.....	.....	.....	.....	.....	.....	.....	.....	0.0570	.....	.....	.....	.....	.....	
28	.....	19.42	.....	.....	.....	.....	.....	.....	.....	.....	0.0430	.....	.....	.....	.....	.....	
29	.....	18.44	.....	.....	.....	.....	.....	.....	.....	.....	0.0467	.....	.....	.....	.....	.....	
30	.....	19.36	.....	.....	.....	.....	.....	.....	.....	.....	0.0230	.....	.....	.....	.....	.....	
31	.....	21.83	.....	.....	.....	.....	.....	.....	.....	.....	0.1933	.....	.....	.....	.....	.....	
1881.																	
Jan. 3	.....	23.86	.....	.....	.....	.....	.....	.....	.....	.....	0.1464	.....	.....	.....	.....	.....	
4	.....	23.96	.....	.....	.....	.....	.....	.....	.....	.....	0.1487	.....	.....	.....	.....	.....	
5	.....	23.85	.....	.....	.....	.....	.....	.....	.....	.....	0.1404	.....	.....	.....	.....	.....	
6	.....	23.84	.....	.....	.....	.....	.....	.....	.....	.....	0.1404	.....	.....	.....	.....	.....	
7	.....	23.60	.....	.....	.....	.....	.....	.....	.....	.....	0.1404	.....	.....	.....	.....	.....	

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS MO.—Continued.

Date.	Time.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope per 1,000.	Sediment.					Method.
												Milligrams in 500 cubic centimeters.				Parts in 100,000.	
												Surface.	Middle depth.	Bottom.	Mean.		
1881.			*Feet.*	*Square feet.*	*Ft. per sec.*	*C ft. per sec.*	*Square feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
Jan. 8	.....	23.56	.....	.....	.....	.....	.....	.....	.....	.....	0.1264	.....	.....	.....	.....	.....	
10	.....	23.37	.....	.....	.....	.....	.....	.....	.....	.....	0.1205	.....	.....	.....	.....	.....	
11	.....	23.51	.....	.....	.....	.....	.....	.....	.....	.....	0.1217	.....	.....	.....	.....	.....	
12	.....	23.66	1,506	22,278	2.39	52,268.4	80,604	24.4	9,575	.....	0.1294	.....	.....	.....	.....	.....	M
13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.1275	.....	.....	.....	.....	.....	
14	.....	23.38	1,506	21,664	2.25	48,783.6	80,412	24.4	192	.....	0.1231	.....	.....	.....	.....	.....	
15	.....	23.41	1,506	21,355	2.20	46,985.4	80,058	24.3	354	.....	0.1205	29	70	80	62	12	
17	.....	23.41	1,506	21,298	2.21	47,186.1	80,001	24.2	57	.....	0.1170	.....	.....	.....	.....	.....	
18	.....	23.42	1,506	21,972	2.20	48,327.3	80,660	24.4	.....	659	.....	.....	.....	.....	.....	.....	
19	.....	23.47	1,506	22,307	2.18	49,499.1	80,920	24.5	.....	260	0.1146	.....	.....	.....	.....	.....	
20	.....	23.48	1,506	22,053	2.33	51,480.9	80,651	24.4	269	.....	0.1111	.....	.....	.....	.....	.....	
21	.....	23.47	1,506	21,588	2.37	51,029.1	80,201	24.3	450	.....	0.1088	.....	.....	.....	.....	.....	
22	.....	23.32	1,506	20,904	2.35	49,090.5	79,743	24.3	458	.....	0.1014	29	85	64	66	12	
24	.....	23.11	1,506	19,711	2.30	45,191.7	78,866	23.9	877	.....	0.1029	.....	.....	.....	.....	.....	
25	.....	23.01	1,506	20,618	2.32	47,926.8	79,923	24.2	.....	1,057	0.0971	.....	.....	.....	.....	.....	
26	.....	22.88	1,506	20,476	2.25	46,142.1	79,976	24.2	.....	53	.....	.....	.....	.....	.....	.....	
27	.....	22.74	1,506	20,609	2.20	45,330.3	80,319	24.3	.....	343	0.0924	.....	.....	.....	.....	.....	
28	.....	22.79	1,506	20,672	2.23	46,167.3	80,301	24.3	18	.....	0.0783	.....	.....	.....	.....	.....	
29	.....	22.72	1,506	21,021	2.24	47,171.7	80,755	24.5	.....	454	0.0838	75	62	90	72	15	
31	.....	22.59	1,506	20,116	2.42	48,768.3	80,045	24.3	710	.....	0.0889	.....	.....	.....	.....	.....	
Feb. 1	.....	22.68	1,506	19,966	2.45	49,125.6	79,759	24.2	286	.....	0.0924	.....	.....	.....	.....	.....	
2	.....	22.50	1,506	20,197	2.47	49,969.8	80,261	24.3	.....	502	0.0702	.....	.....	.....	.....	.....	
3	.....	22.51	1,506	19,998	2.40	48,168.9	80,047	24.3	214	.....	0.0877	.....	.....	.....	.....	.....	M.
4	.....	22.38	1,506	19,661	2.38	46,565.1	79.906	24.2	141	.....	0.0854	.....	.....	.....	.....	.....	M.
5	.....	22.34	1,506	19,848	2.42	47,127.6	80.153	24.3	.....	247	0.0842	90	81	111	91	19	M.
7	.....	22.84	.....	.....	.....	.....	.....	.....	.....	.....	0.0995	.....	.....	.....	.....	.....	
8	.....	23.85	.....	.....	.....	.....	.....	.....	.....	.....	0.1065	.....	.....	.....	.....	.....	
9	.....	24.13	.....	.....	.....	.....	.....	.....	.....	.....	0.1696	.....	.....	.....	.....	.....	

Ellis No. 10.....

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS, MO.—Continued.

Date.	Gauge.	Main river.				Slough.				Total.						Method
		Water width.	Water area.	Mean velocity.	Discharge.	Water width.	Water area.	Mean velocity.	Discharge.	Water area.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	
1881.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*C. ft. pr. sec.*	*Feet.*	*Sq. feet.*	*Ft. pr. sec.*	*C. ft p. sec.*	*Sq. feet.*	*C. ft. pr. sec.*	*Sq. feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	
Feb. 21	29.08	.....	29,101.6	3.74	109,062.1	450	600	0.0	0.0	29,701.6	109,062.1	.....	.....	.....	.....	I. C.
22	28.93	.....	29,101.6	4.01	116,820.4	400	500	0.0	0.0	29,601.6	116,820.4	.....	.....	.....	.....	I. C.
25	29.20	1,649	29,863.0	4.27	127,652.0	480	600	0.0	0.0	30,463.0	127,652.0	79,943	24.2	210	.....	R. with P.
26	28.53	1,555	29,785.0	4.03	120,107.0	300	300	0.0	0.0	30,085.0	120,107.0	.....	.....	.....	.....	R. with P.
Mar. 1	28.73	.....	29,101.6	4.73	137,617.1	330	400	0.0	0.0	29,501.6	137,617.1	.....	.....	.....	.....	I. C.
2	29.98	.....	29,101.6	4.26	123,932.6	560	1,000	0.0	0.0	30,101.6	123,932.6	.....	.....	.....	.....	I. C.
8	30.83	.....	49,030.3	4.02	197,242.2	650	1,500	0.0	0.0	50,530.3	197,242.2	.....	.....	.....	.....	I. C.
9	30.56	.....	49,030.3	3.94	193,350.6	625	1,400	0.0	0.0	50,430.3	193,350.6	.....	.....	.....	.....	I. C.
10	30.16	.....	49,030.3	4.12	202,137.4	600	1,100	0.0	0.0	50,130.3	202,137.4	.....	.....	.....	.....	I. C.
12	30.26	2,175	50,132.0	4.89	245,164.0	610	1,150	0.0	0.0	51,282.0	245,164.0	97,662	29.6	.....	17,719	R.
14	34.56	2,228	52,055	6.05	314,979	820	4,200	0.0	0.0	56,235	314,979	90,072	27.3	7,590	.....	.....
16	35.46	2,275	55,921	6.10	341,315	860	4,900	1.55	7,595	60,851	348,910	91,905	27.8	.....	1,833	.....
17	35.86	2,255	57,325	6.61	378,760	890	5,275	1.60	8,440	62,600	387,200	92,398	28.0	.....	493	.....
21	36.86	2,300	55,620	6.43	357,782	934	6,202	2.00	12,404	61,822	370,186	88,430	26.8	3,968	.....	.....
22	36.21	2,300	55,653	6.65	370,131	918	5,477	1.79	9,803	62,130	379,934	90,835	27.6	.....	2,405	.....
23	35.71	2,237	60,658	6.08	369,907	998	4,872	1.25	6,090	65,730	375,997	96,048	29.1	.....	5,213	.....
24	35.41	2,318	59,012	6.11	360,697	916	4,484	1.53	6,860	63,496	367,557	94,784	28.7	1,264	.....	.....
25	35.66	2,333	58,983	5.97	351,836	900	4,881	1.62	7,807	63,864	359,643	94,343	28.6	441	.....	.....
26	35.96	2,356	61,069	6.17	376,914	889	5,063	1.85	9,367	66,132	386,281	95,639	29.0	.....	1,296	.....
28	35.91	2,321	55,965	5.98	354,743	923	4,997	1.69	8,445	60,962	363,188	90,631	27.5	5,008	.....	R.
Oct. 11	35.57	2,153	48,080	6.03	289,970	860	4.450	0.20	890	52,530	290,860	83,888	25.1	.....	3,261	M.
12	35.73	2,153	48,080	5.35	305,257	860	4,700	0.35	1,645	52,780	306,902	83,888	.....	.....	.....	M.
14	35.69	2,153	48,080	5.54	266,118	860	4,600	0.30	1,380	52,680	267,498	83,888	.....	.....	.....	M.

.....Base line survey.

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS, MO.—Continued.

Date.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope.	Sediment.					Method.
											Milligrams in 500 cubic centimeters.				Parts in 100,000.	
											Surface.	Middle depth.	Bottom.	Mean.		
1881.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*C. ft. pr. sec.*	*Sq. feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Ft. pr.* 1,000						
Apr. 1	40.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
4	40.70	.....	.....	.....	.....	.....	.....	.....	.....	0.2126	.....	.....	.....	.....	.....	
5	40.59	.....	.....	.....	.....	.....	.....	.....	.....	0.1986	.....	.....	.....	.....	.....	
6	40.03	.....	.....	.....	.....	.....	.....	.....	.....	0.1800	.....	.....	.....	.....	.....	
7	40.13	.....	.....	.....	.....	.....	.....	.....	.....	0.1817	.....	.....	.....	.....	.....	
8	41.35	.....	.....	.....	.....	.....	.....	.....	.....	0.2063	.....	.....	.....	.....	.....	
9	41.98	.....	.....	.....	.....	.....	.....	.....	.....	0.2050	.....	.....	.....	.....	.....	
11	42.07	.....	.....	.....	.....	.....	.....	.....	.....	0.1937	.....	.....	.....	.....	.....	
12	42.27	.....	.....	.....	.....	.....	.....	.....	.....	0.2224	.....	.....	.....	.....	.....	
13	42.75	3,196	84,074.8	5.82	489,448.9	91,466	27.7	.....	835	0.2326	.....	.....	.....	.....	.....	R.
14	43.26	3,269	92,354.9	6.69	624,024.0	98,097	29.7	.....	6,631	0.2250	.....	.....	.....	.....	.....	
15	43.61	3,290	86,056.6	6.47	557,202.0	90,651	27.5	7,446	.....	0.2309	.....	.....	.....	.....	.....	
16	43.80	3,270	93,073.1	6.70	623,100.5	97,044	29.4	.....	6,393	0.2258	.....	.....	.....	.....	.....	
18	43.53	3,286	92,454.6	6.41	592,808.3	97,311	29.5	.....	267	0.2037	.....	.....	.....	.....	.....	
19	42.61	3,298	90,426.5	5.70	515,753.7	98,311	29.8	.....	1,000	0.2072	.....	.....	.....	.....	.....	
20	42.19	3,277	84,655.3	6.14	519,410.3	93,921	28.5	4,390	.....	0.1799	.....	.....	.....	.....	.....	
21	42.12	3,258	79,596.4	6.24	496,470.0	89,091	27.0	4,830	.....	0.1799	.....	.....	.....	.....	.....	
22	42.44	3,278	88,361.7	5.95	525,994.0	96,811	29.4	.....	7,720	0.1912	.....	.....	.....	.....	.....	
23	43.28	3,280	91,954.2	6.24	573,618.3	97,649	29.6	.....	838	0.1599	642	1,168	1,226	1,012	202	
25	45.42	3,280	97,621.0	6.14	599,384.0	96,297	29.4	1,352	.....	0.1633	1,094	1,541	1,450	1,407	272	
26	45.98	3,315	98,890.0	6.56	648,324.0	95,720	28.9	577	.....	.....	692	1,284	1,624	1,200	240	
27	46.33	3,296	104,930.0	6.78	711,098.0	100,603	30.5	.....	4,883	0.2399	.....	.....	.....	.....	.....	
28	46.76	3,298	105,873.0	6.32	669,201.0	100,128	30.3	475	.....	0.2622	.....	.....	.....	.....	.....	
29	47.06	3,296	104,884.0	6.38	669,286.0	98,150	29.8	1,978	.....	0.2121	.....	.....	.....	.....	.....	
30	47.38	3,275	105,653.0	6.37	673,427.0	97,868	29.7	282	.....	0.2320	677	977	1,033	916	179	
May 2	48.55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
3	49.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	999	1,074	735	971	187	
4	49.97	3,345	120,913.0	7.41	895,637.0	104,555	31.7	.....	6,687	.....	875	1,070	1,166	1,045	207	
6	50.17	3,347	122,465.0	6.29	770,036.0	105,438	31.9	.....	883	.....	496	793	861	736	143	
7	49.68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
9	46.76	3,331	98,293.0	6.01	591,027.0	92,652	28.1	12,786	.....	.....	187	494	573	437	84	
10	44.19	3,306	89,547.0	5.35	479,165.0	92,436	28.0	216	.....	.....	336	429	503	424	85	
11	43.16	3,305	86,471.0	5.56	481,165.0	92,765	28.1	.....	329	.....	468	443	526	470	96	
12	42.34	3,297	82,720.0	5.36	443,419.0	91,720	27.8	1,045	.....	.....	298	507	548	465	90	
16	40.94	3,295	76,519.0	5.10	389,883.0	90,133	27.3	1,587	.....	.....	.....	.....	.....	.....	.....	R.

Base line.....

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS, MO.—Continued.

Date.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope.	Sediment.					Method.
											Milligrams in 500 cubic centimeters.				Parts in 100,000.	
											Surface.	Middle depth.	Bottom.	Mean.		
1881.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*C. ft. per sec.*	*Sq. feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Ft. per M.*						
Aug. 8	28.12	1,755	40,748	3.58	145,754	90,585	27.1	744	.....	.0210	265	417	442	385	75	R
9	27.75	1,741	40,413	3.40	137,491	90,917	27.2	.....	332	.0358	.....	.....	.....	.....	.....	.....
10	27.33	1,731	40,011	3.21	128,643	91,226	27.3	.....	327	.0441	.....	.....	.....	.....	.....	.....
11	26.99	1,714	39,693	3.41	135,442	91,494	27.4	.....	268	.0398	.....	.....	.....	.....	.....	.....
12	26.67	1,712	39,538	3.54	139,775	91,887	27.5	.....	393	.0241	430	524	381	440	82	
13	26.30	1,705	37,733	3.29	124,186	90,714	27.2	1,173	.....	.0293	316	362	260	325	63	
15	25.52	1,683	36,429	3.22	117,403.6	90,734	27.2	.....	17	.....	288	328	316	315	62	
16	25.29	1,659	34,531	3.31	114,267	89,220	26.7	1,514	.....	.0160	307	333	311	321	63	
17	25.14	1,665	34,944	3.16	110,422	89,882	26.9	.....	662	.0105	303	.....	357	330	66	
18	25.01	1,665	35,142.0	3.12	109,643.0	90,296	27.1	.....	414	.0023	262	312	276	291	57	
19	24.88	1,662	34,526.1	2.97	102,650.8	89,896	26.9	400	.....	.....	212	.....	304	258	52	
20	24.76	1,644	35,009.9	3.08	107,907.9	90,568	27.1	.....	672	.....	.....	.....	.....	.....	.....	
21	24.61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
22	24.55	1,635	35,248.7	3.01	106,252.5	91,151	27.3	.....	583	.0008	277	311	423	331	67	
23	24.52	1,635	34,261.0	3.17	108,692.9	90,213	27.0	938	.....	.0025	232	247	416	286	60	
24	24.52	1,635	32,507.8	2.92	95,061.1	88,460	26.5	1,753	.....	.....	223	258	290	257	51	
25	24.35	1,641	32,539.4	2.92	95,035.7	88,769	26.9	.....	309	.0075	231	232	302	249	51	
26	24.20	1,633	30,630.9	2.88	88,428.7	87,106	26.1	1,663	.....	.0030	195	204	236	210	42	
27	24.02	1,624	31,686.4	2.94	93,203.2	87,455	26.5	.....	1,349	.....	209	220	258	227	46	
29	23.66	1,614	29,896.6	2.86	85,652.8	87,247	26.1	1,208	.....	.0013	210	186	236	205	41	
30	23.54	1,603	30,662.2	2.82	86,455.9	88,205	26.4	.....	958	.0018	226	238	449	288	61	
31	23.41	1,605	30,196.8	2.81	84,877.9	87,948	26.3	257	.....	.....	217	236	237	232	46	
Sept. 1	23.29	1,605	30,563.6	2.94	89,964.6	88,507	26.5	.....	559	.....	202	243	266	239	47	R
2	23.25	1,605	30,378.3	2.89	87,917.2	88,386	26.5	121	.....	.....	265	.....	391	328	66	R
3	23.23	1,608	29,706.1	3.17	94,069.0	87,746	26.3	640	.....	.....	246	269	109	223	42	R
5	23.27	1,600	29,456.1	3.17	93,316.2	87,432	26.2	314	.....	.0068	240	254	262	253	50	R
6	23.30	1,600	29,160.7	3.05	88,888.0	87,089	26.1	343	.....	.....	.....	.....	.....	.....	.....	R
7	23.35	1,602	30,278.6	3.01	91,048.0	88,127	26.4	.....	1,038	.....	.....	.....	.....	.....	.....	R
8	23.43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	R
9	23.55	1,602	30,278.6	3.04	92,054.2	87,807	26.3	320	.....	.0048	.....	.....	.....	.....	.....	R
10	23.74	1,602	30,278.6	3.75	113,711.4	87,503	26.2	304	.....	.0055	.....	.....	.....	.....	.....	R
12	24.26	1,629	30,206.1	3.41	103,879.8	86,590	25.9	913	.....	.....	.....	.....	.....	.....	.....	R
				3.65	110,191.1											M
13	24.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
14	24.73	1,620	31,628.3	4.01	126,994.9	87,248	26.1	.....	658	.0060	.....	.....	.....	.....	.....	M
15	24.94	1,650	32,059.9	3.76	120,551.2	87,337	26.2	.....	89	.0018	.....	.....	.....	.....	.....	R
				3.56	114,007.9											M

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS, MO.—Continued.

Date.	Gauge.	Water width.	Water area.	Mean velocity.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.	Slope.	Sediment.					Method.
											Milligrams in 500 cubic centimeters.				Parts in 100,000.	
											Surface.	Middle depth.	Bottom.	Mean.		
1881.		*Feet.*	*Sq. feet.*	*Ft. per sec.*	*C. ft. per sec.*	*Sq. feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Ft. per M.*						
Sept. 16	25.24	1,669	31,765.6	3.67	116,479.7	86,544	25.9	793	.....	.0030	.....	.....	.....	.....	.....	R
17	25.67	1,683	31,827.0	3.86	122,795.5	85,879	25.4	665	.....	.....	.....	.....	.....	.....	.....	R
19	26.05	1,698	32,286.2	3.81	123,020.2	85,696	25.6	183	.....	.0070	.....	.....	.....	.....	.....	R
20	26.29	1,695	33,987.4	4.08	138,591.6	86,990	26.1	.....	1,294	.0348	.....	.....	.....	.....	.....	R
21	26.38	.....	.....	.....	.....	.....	.....	.....	.....	.0700	.....	.....	.....	.....	.....	R
22	26.55	1,695	33,986.8	4.33 4.92	147,340.5 167,339.7	86,549	25.8	441	.....	.0850	.....	.....	.....	.....	.....	R M
23	26.68	.....	.....	.....	.....	.....	.....	.....	.....	.0436	.....	.....	.....	.....	.....	
24	26.79	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
27	27.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
28	27.65	.....	.....	.....	.....	.....	.....	.....	.....	.0627	.....	.....	.....	.....	.....	
29	27.82	.....	.....	.....	.....	.....	.....	.....	.....	.0514	.....	.....	.....	.....	.....	
30	28.05	.....	.....	.....	.....	.....	.....	.....	.....	.0500	.....	.....	.....	.....	.....	
Oct. 1	29.20	.....	.....	.....	.....	.....	.....	.....	.....	.0590	.....	.....	.....	.....	.....	
3	32.16	.....	.....	.....	.....	.....	.....	.....	.....	.1075	.....	.....	.....	.....	.....	
4	34.60	.....	.....	.....	.....	.....	.....	.....	.....	.0897	.....	.....	.....	.....	.....	
5	34.62	.....	.....	.....	.....	.....	.....	.....	.....	.1110	.....	.....	.....	.....	.....	
6	34.62	.....	.....	.....	.....	.....	.....	.....	.....	.1283	.....	.....	.....	.....	.....	
7	34.88	.....	.....	.....	.....	.....	.....	.....	.....	.1414	.....	.....	.....	.....	.....	
8	35.01	.....	.....	.....	.....	.....	.....	.....	.....	.1414	.....	.....	.....	.....	.....	
10	35.53	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
11	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
12	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
14	(*)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
15	35.46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
17	35.08	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
18	35.61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
19	36.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
20	37.53	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
21	38.61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
22	39.18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
24	39.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
25	40.45	.....	.....	.....	.....	.....	.....	.....	.....	.1128	.....	.....	.....	.....	.....	
26	40.71	.....	.....	.....	.....	.....	.....	.....	.....	.1639	.....	.....	.....	.....	.....	
27	40.70	3,305	79,889.1	6.82	545,132	93,945	28.2	(Oct. 11.)	10,057	.1308	.....	.....	.....	.....	.....	M
28	40.38	3,280	79,889	5.80	463,372	94,998	28.5	.....	1,053	.1404	.....	.....	.....	.....	.....	M
29	40.04	.....	.....	.....	.....	.....	.....	.....	.....	.1464	.....	.....	.....	.....	.....	M
31	39.48	3,188	74,737	5.82	439,905	92,757	27.8	2,241	.....	.1393	.....	.....	.....	.....	.....	M

Nov.	1	39.52	3,188	72,123	6.35	457,976	90,016	27.0	2,741	.....	.1426	.....	.....	.....	.....	.....	M
	2	39.61	.....	.....	.....	.....	.....	.....	.....	.....	.1221	.....	.....	.....	.....	.....	M
	3	39.77	.....	.....	.....	.....	.....	.....	.....	.....	.1388	.....	.....	.....	.....	.....	M
	4	39.90	3,229	72,564	7.62	552,834	89,238	26.7	778	.....	.1440	.....	.....	.....	.....	.....	M
	5	40.07	.....	.....	.....	.....	.....	.....	.....	.....	.1053	.....	.....	.....	.....	.....	M
	7	40.02	.....	.....	.....	.....	.....	.....	.....	.....	.1353	.....	.....	.....	.....	.....	
	8	40.10	.....	.....	.....	.....	.....	.....	.....	.....	.1524	.....	.....	.....	.....	.....	
	9	40.12	.....	.....	.....	.....	.....	.....	.....	.....	.1590	.....	.....	.....	.....	.....	
	10	39.97	.....	.....	.....	.....	.....	.....	.....	.....	.1476	.....	.....	.....	.....	.....	
	11	39.71	.....	.....	.....	.....	.....	.....	.....	.....	.1363	.....	.....	.....	.....	.....	
	12	39.89	.....	.....	.....	.....	.....	.....	.....	.....	.1288	.....	.....	.....	.....	.....	
	14	40.23	.....	.....	.....	.....	.....	.....	.....	.....	.1401	.....	.....	.....	.....	.....	
	15	41.36	.....	.....	.....	.....	.....	.....	.....	.....	.1762	.....	.....	.....	.....	.....	
	16	41.74	.....	.....	.....	.....	.....	.....	.....	.....	.1805	.....	.....	.....	.....	.....	
	17	41.79	.....	.....	.....	.....	.....	.....	.....	.....	.1677	.....	.....	.....	.....	.....	

*See record for March, 1881.

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS, MO.—Continued.

Date.	Gauge.	Main river.				Slough.			
		Water width.	Water area.	Mean velocity.	Discharge.	Water width.	Water area.	Mean velocity.	Discharge.
1881.		*Feet.*	*Sq. feet.*	*Ft. p. sec.*	*Cu. ft. p. sec.*	*Feet.*	*Sq. feet.*	*Ft. p. sec.*	*C. ft. p. sec.*
May 17	40.61	3,294	78,502	5.13	402,847	.....	.....	.....	.....
18	40.54	3,262	78,301	5.10	398,866	.....	.....	.....	.....
19	40.65	3,250	78,901	5.22	402,092	.....	.....	.....	.....
20	40.63	3,272	81,318	5.16	419,252	.....	.....	.....	.....
21	40.53	3,272	81,664	5.14	419,807	.....	.....	.....	.....
23	40.15	.....	.....	.....	.....	.....	.....	.....	.....
24	40.20	3,272	78,578	5.18	407,177	.....	.....	.....	.....
25	40.62	3,294	78,485	5.10	400,396	.....	.....	.....	.....
26	40.65	3,251	78,994	5.31	419,466	.....	.....	.....	.....
27	40.30	2,260	69,106	5.38	371,757	1,012	8,623	2.23	19,229
28	39.52	2,249	66,877	5.40	361,070	1,020	7,213	2.12	15,292
30	37.71	2,214	61,690	5.18	320,613	965	6,237	1.40	6,925
31	37.00	2,198	59,421	5.12	304,217	955	6,183	1.12	6,925
June 1	36.40	2,185	59,050	5.24	309,642	965	5,349	0.90	4,814
2	35.97	2,156	60,705	4.94	299,781	911	5,128	0.60	3,077
3	35.96	.....	.....	.....	.....	.....	.....	.....	.....
4	36.50	2,193	60,716	5.13	312,354	955	4,963	0.92	4,571
6	37.12	2,208	61,768	5.21	321,837	976	5,639	1.20	6,769
7	36.89	2,206	57,268	5.41	309,655	976	5,314	1.12	5,952
8	36.39	2,196	59,109	5.42	320,756	971	5,170	0.85	4,395
9	36.18	2,211	58,871	5.24	308,597	965	4,657	0.72	3,353
10	36.20	2,190	58,067	5.11	296,859	955	4,526	0.73	3,304
13	37.07	2,210	60,544	5.17	313,217	987	5,947	1.14	6,780
14	37.85	2,241	63,326	5.43	344,027	986	6,099	1.45	8,844
15	37.90	2,223	61,744	5.11	315,480	986	6,026	1.47	8,858
16	37.68	2,224	63,916	5.51	352,251	981	5,962	1.39	8,287
17	37.87	2,219	61,061	5.57	340,033	981	5,873	1.46	8,575
18	38.17	2,229	64,124	5.10	327,103	992	5,798	1.54	8,929
20	39.90	2,265	68,806	5.74	394,802	1,029	7,935	1.86	14,879
21	40.26	.....	.....	.....	.....	.....	.....	.....	.....
22	40.07	2,249	72,348	5.87	424,436	1,023	7,297	1.91	13,837
23	40.01	2,253	68,922	5.74	395,544	1,018	7,775	1.90	14,773
24	40.00	2,229	65,920	5.65	372,385	1,043	8,019	1.90	15,236
25	40.13	2,249	68,966	5.73	395,085	1,023	8,522	1.92	16,362
27	39.56	.....	.....	.....	.....	.....	.....	.....	.....
28	39.18	2,247	66,928	5.90	394,861	997	7,149	1.76	12,582
29	38.87	2,228	65,987	5.51	363,483	997	6,914	1.70	11,754
July 1	38.36	2,226	64,918	5.64	365,909	1,002	6,251	1.58	9,877
2	39.41	2,263	68,678	5.62	385,709	1,008	7,490	1.81	13,557
5	40.03	2,260	67,796	6.08	412,368	1,012	9,027	1.91	17,241
6	39.73	2,253	64,693	6.01	389,112	1,007	8,167	1.86	15,191
7	38.89	2,233	63,251	5.60	354,277	997	7,141	1.70	13,540
8	37.70	.....	.....	.....	.....	.....	.....	.....	.....
9	36.55	.....	.....	.....	.....	.....	.....	.....	.....
11	34.13	2,127	52,730	5.25	276,659	810	3,850	0.00	0
12	33.42	2,121	48,985	4.38	214,794	770	3,300	0.00	0
13	33.13	.....	.....	.....	.....	.....	.....	.....	.....
14	33.68	2,106	53,036	4.72	250,496	790	3,500	0	0
15	34.56	.....	.....	.....	.....	.....	.....	.....	.....
16	35.47	2,143	57,613	5.30	305,482	860	4,000	0	0
18	36.50	2,172	58,471	4.97	290,590	930	4,950	0	0
19	36.85	2,195	59,654	5.21	310,363	930	5,200	0	0
20	37.15	2,195	60,672	5.07	308,032	955	5,300	1.22	6,466
21	37.39	.....	.....	.....	.....	.....	.....	.....	.....
22	37.45	.....	.....	.....	.....	.....	.....	.....	.....
23	37.45	2,202	63,204	5.40	341,280	969	5,765	1.32	7,610
25	36.99	.....	.....	.....	.....	.....	.....	.....	.....
26	36.30	2,199	59,808	5.36	310,564	898	4,529	0.81	3,668
27	35.04	.....	.....	.....	.....	.....	.....	.....	.....
28	33.64	2,146	51,660	4.99	257,896	856	2,781	0	0
29	32.27	.....	.....	.....	.....	.....	.....	.....	.....
30	31.56	2,026	47,856	4.48	214,295	680	1,100	0	0
Aug. 1	30.78	.....	.....	.....	.....	.....	.....	.....	.....
2	30.49	2,020	45,414	4.14	188,035	530	440	0	0
3	30.12	.....	.....	.....	.....	.....	.....	.....	.....
4	29.71	1,819	43,288	4.41	190,950	420	100	0	0
5	29.52	1,811	43,866	4.08	179,174	0	0	0	0
6	29.06	1,790	43,155	4.29	185,183	.....	.....	.....	.....

CURRENT AND SEDIMENT OBSERVATIONS AT SAINT LOUIS, MO.—Continued.

Date.	Total.						Slope per 1,000.	Sediment.					Method.
								M'g'rs in 500 c. c.				Parts in 100,000.	
	Water area.	Discharge.	Datum area.	Datum depth.	Fill.	Scour.		Surface.	Middle depth.	Bottom.	Mean.		
1881.	*Feet.*	*Sq. feet.*	*Ft. p sec.*	*Feet.*	*Sq. feet.*	*Sq. feet.*							
May 17	78,502	402,847	93,203	28.2	.....	3,070	.....	273	448	434	401	77	R.
18	78,301	398,866	93,175	28.2	28	.....	.....	342	408	411	392	77	
19	78,901	402,092	93,417	28.3	.....	242	.....	310	409	434	341	77	
20	81,318	419,252	95,899	29.1	.....	2,482	.....	190	419	427	364	69	
21	81,664	419,807	96,572	29.3	.....	673	.....	344	426	526	431	86	
23	.....	.....	.....	.....	.....	.....	0.1275	.....	.....	.....	.....	.....	
24	78,578	407,177	94,566	28.7	2,006	.....	0.1351	300	373	.....	349	67	
25	78,485	400,396	93,095	28.2	1,471	.....	0.1351	629	565	533	576	115	
26	78,994	419,466	93,506	28.3	.....	411	0.1401	.....	.....	.....	.....	.....	
27	77,729	390,986	93,382	28.3	124	.....	0.1811	.....	.....	.....	.....	.....	
28	74,090	376,762	92,293	27.9	1,089	.....	0.1026	362	461	559	461	92	
30	67,927	327,538	91,965	27.7	328	.....	.....	315	416	452	400	79	
31	65,604	311,142	91,890	27.8	75	.....	0.1092	385	424	424	414	82	
June 1	64,399	314,456	92,575	28.1	.....	685	.....	389	457	579	471	95	
2	65,833	302,858	95,345	27.7	.....	2,770	0.1055	405	489	562	486	97	
3	.....	.....	.....	.....	.....	.....	0.0992	.....	.....	.....	.....	.....	
4	65,684	316,925	93,549	28.3	1,796	.....	0.1281	.....	.....	.....	.....	.....	
6	67,407	328,606	93,309	28.3	240	.....	0.0767	847	914	937	903	180	
7	62,582	315,607	89,210	27.0	4,089	.....	0.0967	.....	.....	.....	.....	.....	
8	64,279	325,151	92,494	28.0	.....	3,284	0.1005	.....	.....	.....	.....	.....	
9	63,528	311,950	92,409	28.0	85	.....	0.0992	794	855	735	810	159	
10	62,593	300,163	91,411	27.7	998	.....	0.0917	587	934	857	828	159	
13	66,491	319,997	92,550	28.0	.....	1,139	0.1018	736	852	931	843	168	
14	69,425	352,871	92,979	28.2	.....	429	0.1080	788	953	1,083	944	188	
15	67,770	324,338	91,163	27.8	1,816	.....	0.1281	769	818	776	795	158	
16	69,878	360,538	93,976	28.5	.....	2,813	0.1143	620	676	809	695	140	
17	66,934	348,608	90,423	27.4	3,553	.....	0.1043	699	.....	678	689	138	
18	69,922	336,032	92,448	28.0	.....	2,025	0.0992	.....	.....	.....	.....	.....	
20	76,741	409,681	93,631	28.4	.....	1,183	0.1273	786	1,056	.....	966	184	
21	.....	.....	.....	.....	.....	.....	0.1299	.....	.....	.....	.....	.....	
22	79,645	438,263	95,879	29.1	.....	2,248	0.1248	941	1,200	1,112	1,113	217	
23	76,697	410,317	93,127	28.2	2,752	.....	0.1199	1,516	1,170	1,276	1,283	264	
24	73,939	387,621	90,402	27.4	2,725	.....	0.1323	1,107	1,057	1,244	1,116	227	
25	77,488	411,447	93,526	28.3	.....	3,124	0.1236	994	1,045	1,263	1,087	220	
27	.....	.....	.....	.....	.....	.....	0.1143	.....	.....	.....	.....	.....	
28	74,077	407,443	93,201	28.2	325	.....	0.1170	845	1,077	1,404	1,111	224	
29	72,901	375,237	93,030	28.2	171	.....	0.1218	1,398	1,442	1,412	1,424	283	
July 1	71,169	405,786	92,943	28.2	87	.....	0.1272	1,374	1,503	1,555	1,484	295	
2	73,168	399,266	91,530	27.7	1,413	.....	0.1469	1,566	1,787	1,694	1,689	336	
5	76,823	429,609	93,156	28.2	.....	1,626	0.1549	.....	1,398	1,388	1,395	279	
6	72,860	404,303	90,170	27.3	2,936	.....	0.1281	1,107	1,279	1,296	1,240	245	
7	70,392	367,817	90,428	27.4	.....	258	0.1218	1,118	1,115	1,392	1,185	242	
8	.....	.....	.....	.....	.....	.....	0.1092	.....	.....	.....	.....	.....	
9	.....	.....	.....	.....	.....	.....	0.0917	1,068	1,078	1,260	1,121	227	
11	56,580	276,659	91,295	27.7	.....	867	0.1710	.....	808	930	849	174	
12	52,285	214,794	89,069	27.0	2,226	.....	.....	842	899	966	904	181	
13	.....	.....	.....	.....	.....	.....	0.0837	.....	.....	.....	.....	.....	
14	56,536	250,496	92,567	28.1	.....	3,498	0.0646	1,119	1,315	1,354	1,276	253	
15	.....	.....	.....	.....	.....	.....	0.0488	.....	.....	.....	.....	.....	
16	61,013	305,483	91,764	27.5	803	.....	0.0947	.....	1,263	1,287	1,271	255	
18	63,421	290,590	91,029	27.6	735	.....	.....	1,076	.....	1,202	1,139	228	
19	64,854	310,863	91,372	27.7	.....	343	0.1140	1,347	1,238	1,344	1,292	262	
20	65,972	314,498	91,549	27.7	.....	177	0.0977	1,136	1,084	931	1,059	210	
21	.....	.....	.....	.....	.....	.....	0.1053	.....	.....	.....	.....	.....	
22	.....	.....	.....	.....	.....	.....	0.1103	.....	.....	.....	.....	.....	
23	68,960	348,890	93,598	28.4	.....	2,049	0.1128	.....	.....	.....	.....	.....	
25	.....	.....	.....	.....	.....	.....	0.1153	.....	.....	.....	.....	.....	
26	64,337	314,232	92,570	28.1	1,028	.....	0.0952	503	.....	524	513	103	
27	.....	.....	.....	.....	.....	.....	0.0952	.....	.....	.....	.....	.....	
28	54,441	257,896	90,787	27.5	1,783	.....	0.1013	504	567	585	556	110	
29	.....	.....	.....	.....	.....	.....	0.0702	.....	.....	.....	.....	.....	
30	48,956	214,295	91,238	27.6	.....	451	0.0526	.....	438	398	425	84	
Aug. 1	.....	.....	.....	.....	.....	.....	0.0434	.....	.....	.....	.....	.....	
2	45,854	188,035	90,947	27.6	291	.....	0.0493	338	409	385	385	75	
3	.....	.....	.....	.....	.....	.....	0.0471	.....	.....	.....	.....	.....	
4	43,388	190,950	90,349	27.0	598	.....	0.0406	367	378	352	369	73	
5	43,866	179,174	91,212	27.4	.....	863	0.0609	388	383	360	379	75	
6	43,155	185,183	91,329	27.4	.....	117	0.0433	364	378	366	374	75	R.

Base line.

APPENDIX G.

REPORT OF ASSISTANT ENGINEER J. A. OCKERSON, UPON THE FIELD OPERATIONS OF THE TOPOGRAPHICAL AND HYDROGRAPHICAL PARTY UNDER HIS CHARGE, SEASON OF 1881–'82.

OFFICE MISSISSIPPI RIVER COMMISSION,
April 17, 1882.

SIR: I have the honor to make the following report concerning the work done by the party under my charge during the season of 1881 and 1882:

In accordance with your instructions, the party left Saint Louis on October 1 for Saint Louis Landing, Ark., to resume the survey at the latter point. The party was organized as follows: J. A. Ockerson, chief of party; assistants, C. M. Winchell, B. H. Colby, C. W. Clark, L. C. Jones, E. E. Haskell, E. D. Thompson, H. B. Wood; recorders, C. V. Mersereau and Edwin J. Jolley; and a crew consisting of 10 rodmen, 2 leadsmen, 24 axmen, 6 boatmen, 1 steward, 1 cook, and 3 boys; also a launch crew of 1 engineer, 1 steersman, 1 fireman, and 1 deck-hand.

Quarter-boats Mississippi and Louisiana and the tug Frolic were assigned to the party.

Work was begun October 10, a stone line running through △ Saint Louis Landing, and normal to the river, forming the upper limit or starting line.

The assistants were assigned as follows: Topography, C. M. Winchell, B. H. Colby, E. E. Haskell, and E. D. Thompson; levels, L. C. Jones and C. V. Mersereau; hydrography, C. W. Clark and H. B. Wood; plotting, Edwin J. Jolley.

For a short time S. L. Beaumont was engaged in sketching, but afterward took the place of Mr. L. C. Jones, who was granted leave in consequence of sickness in his family.

As a rule, the topographers were in the field every fair day, the plotting being mostly done by Mr. Jolley. Filling in the sketches on the plats was done by the topographers on rainy days.

Soundings occupied the hydrographers about one-half of the time, and during the remainder of the time they were employed in cutting lines, running out levees, lakes, and other topographic features, which were outside of the limits of the topography proper.

The levelers were kept busy nearly all of the time on their main lines and the stone lines. The rest of the time was employed in cutting lines.

The chief of party, aside from the regular executive duties, was employed in hunting up △ stations and putting up signals thereon, establishing stone lines, and making a general reconnaissance of the entire work.

TOPOGRAPHY.

A preliminary computation of the secondary triangulation having been made, giving the approximate lengths and azimuths of triangle sides, this formed the base for the topographical work. All intermediate work was done with the stadia, the courses being frequently checked on △ stations. Among the main topographical features shown are the river banks; outlines of bars, chutes, bayous, sloughs, lakes, swamps, levees; 5-foot contours; approximate limits of cultivation; kinds of timber; houses and fences.

The work is confined to showing general features, but little time being spent in delineating the minor details. In open country the contour lines are developed from numerous elevations, which are taken at such points as will best show the relief of the ground.

In woods the contour lines are developed from sections cut out nearly normal to the ridges. At the time these sections are run, as many side elevations are taken as may be necessary to determine the directions of ridges and sloughs. The work on the sections is checked by reading vertical angles and distances between stakes, both forward and back.

The intervals between sections depend on the nature of the country. Where it was flat, with few changes in surface, the sections were farther apart than where the surface was very irregular, the distances ranging from 400 meters to 800 meters. If the sections ran into lakes, bayous, or swamps, the outlines of the latter were usually located instrumentally. A prismatic compass was sometimes used to good advantage in filling in the details between sections.

In open country the topography extended back $1\frac{1}{2}$ miles and in woods $\frac{3}{4}$ mile. Besides this all levees were located, even where several miles back from the river, and in such cases most of the country between the levee and river was surveyed.

The elevations are determined by means of either the vertical circle or the tele-

scope level, or both combined. They are frequently checked on the benches or turning points of the ordinary levels. The discrepancies are usually quite small, from 0.2 to 0.4 foot being about an average closure for a distance of 3 or 4 miles. The closure of stadia distances, as shown by plotting the courses between ◬ stations, would give an average error of about 1 in 400. This, of course, includes errors of azimuth and errors of plotting.

Twenty-nine stone lines were established, consisting of four stones in a line normal to the channel. Two stones were planted on each side of the river, the first one from 200 to 500 meters from the bank, and the rear stones about half a mile further back. The stones are about 3 feet long and 6 inches square, and are set so as to project about a foot above the surface of the ground.

I would here call attention to the advisability of examining some of these stone lines to see if the stones have been disturbed by the floods.

There have been numerous cases where the stones were planted in open fields and were in sod, where they have been washed completely out from the eddies formed by the current striking them, although the stones projected but a few inches above the ground. If the same thing occurs in the woods it would be well to adopt a different form of permanent marks.

The stones on the stone lines were located with the stadia. Generally the line was established so as to pass through a ◬ station, in which case the positions of the stones were well determined. Where the ◬ stations had been washed out, and the stone line consequently a long distance from them, the positions of the stones as determined cannot be relied upon nearer than from 2 to 8 meters. In cases where the stations were gone the shore ends of the stone lines were usually located by intersections from several stadia stakes.

Section corners were connected with whenever they could be identified.

Number of square miles of topography = 236½. From Saint Louis Landing to Prentiss, a distance of about 57 miles, where the △ stations were about two years old, there were 28 stations gone. From Prentiss to Offuts, about 47 miles, the stations being a year or less old, 30 stations were gone.

CHANGES IN METHODS SUGGESTED.

One of the chief obstacles in the way of good and rapid work is the large portion of timber and brush which, under the present method, necessitates the cutting of lines.

On an average it requires 4 men a day to cut one line, and after it is cut the instrumental work can be done in a couple of hours.

From experiments made during the past season I believe that more work can be done at less expense by a different method, and therefore respectfully recommend that cutting be abandoned except on stone lines, and that the following be substituted in lieu thereof:

In wooded sections use a transit with a good needle and telescope level, determining direction by means of the needle. Start from a known point on shore, run back to the limit of topography, then parallel to shore, say 500 meters, thence back to shore, connecting again on some known point. Completing a circuit will furnish means to check the work. The woods are never so thick, except where there is cane, but that the stadia can be read at least 50 meters distant. In the usual transit method this would require the instrument to be set up and carefully centered so often that but little progress could be made. In the method proposed the instrument is used as follows: Have rod No. 1 held at starting point on shore; set up instrument as far away from rod as it can be seen; read the needle, distance, and vertical angle. Now the instrument becomes a known point. Send rod No. 2 ahead as far as it can be seen, and take same readings to it. Then move instrument beyond rod No. 2, &c. There are several advantages in this method, among which are: Twice the distance can be read from each setting of the instrument; as there is no centering required, the instrument can be set up quicker; the data will cover a larger space, since the line will generally be zigzag.

The usual topographical party requires 1 observer, 1 recorder, and 3 stadia men. A compass party would require an observer, a recorder, and 2 stadia men. With the proper appliances the latter party could run out three or four lines a day. The azimuths being determined with a needle would not introduce any large error in such a short distance.

It would be well to have a card attached to the needle, and graduated from 0° to 360°, and then read from a fixed point with a magnifying glass. The instrument should be firmly attached to the tripod, so that it would not be necessary to box it up between stakes.

HYDROGRAPHY.

Lines, nearly normal to the course of the stream, were sounded at intervals of half a mile, and between them intermediate lines were sounded across bars and extending

far enough to define the low-water shore line. Eight full sections is about an average day's work for one crew.

Lines were run between located signals on shore. The soundings on these lines were about 30 meters apart. About one sounding in three was located by means of angles read with two sextants between three of the shore signals selected so as to give good intersections. Both readings were made at the instant the sounding was taken. The intermediate soundings are located on the flat by interpolation.

The soundings were taken from a six-oared cutter, except in very swift water, when the tug was used. The cutter was used in preference, when practicable, as the soundings could be more uniformly spaced, and because the tug drew too much water to run over bars.

The sounding crew consisted of 1 chief, 1 assistant, and 1 recorder in the stern of the boat; 1 leadsman in the bow; and 6 oarsmen, each pulling a sweep from 14 to 16 feet long.

The lead line used was three-eighths inch Italian hemp, and was marked in feet by means of colored cloth and leather tags. The leads were 2½ to 3 inches diameter at the base and slightly tapering toward top. In the bottom was a hole 1 inch deep and 1 inch in diameter, in which tallow was placed for the purpose of picking up specimens of the river bed. In water less than 50 feet deep a 12-pound lead was used, and beyond that depth a 20-pound lead was found more satisfactory. Sand cups of different patterns were tried, but it was found that a tallowed lead was more reliable. The latter often brings up specimens of gravel as large as a pea. Sand readily adheres to the tallow, and clay generally shows itself on all parts of the lead. The difficulty, however, is that our specimens only show the character of a very thin coating of the surface, except in the case of clay. What we describe from the specimen as being "sand bottom" may be but a thin film overlying a bed of clay.

Some experiments were made relative to changes in length of lead line. It was found that the maximum error due to all changes that would affect the length of the lead line would never exceed nine-tenths of 1 per cent. of the depth. The details of these experiments were given in a special report submitted by Mr. Clark, January 25, 1882.

Experiments were also made to determine the velocity with which a lead would sink in still water and also in a rapid current. The tabulated results are given below:

Depth in feet.	11-pound lead—		Depth in feet.	20-pound lead—	
	Floating with current.	In rapid current.		Floating with current.	In rapid current.
	Velocity per second.			Velocity per second.	
	Feet.	*Feet.*		*Feet.*	*Feet.*
20	9.1	.....	20	.....	.....
25	10.0	.....	25	.....	.....
30	10.7	.....	30	10.8	.....
35	11.3	.....	35	10.8	.....
40	11.8	.....	40	11.5	.....
45	12.2	.....	45	11.8	.....
50	12.2	.....	50	11.9	.....
55	12.2	.....	55	12.2	.....
60	12.0	.....	60	12.4	.....
65	11.9	11.9	65	12.5	12.3
70	11.6	11.3	70	12.7	12.3
75	11.5	10.9	75	12.9	12.3
80	11.3	10.7	80	12.9	12.3
85	11.0	.....	85	13.0	12.3
90	10.8	.....	90	13.0	12.3
95	10.7	.....	95	12.7	12.2
100	10.5	.....	100	12.5	11.9
105	10.3	.....	105	12.3	11.9
110	10.2	.....	110	12.2	11.8
115	.....	.....	115	12.1	11.9
			120	12.0	12.0
Mean	11.1	11.2	Mean	12.2	12.1

In the above experiments a ⅝-inch lead-line was used. It will be observed that where the heavy lead was used the velocity is about 10 per cent. greater. The velocity in still water does not differ materially from that in a rapid current. In the case of the light lead, there is an accelerating motion till it reaches a depth of about 50 feet, and it is then gradually retarded. In the case of the heavy lead, the accelerating motion

continues to a depth of about 85 feet. The retarding is probably due to the buoyancy of the line and the increasing density of the water.

The experiments are limited in number and not sufficient to give exact results, but will serve to show the tendency under the conditions named.

The results seem to show that a large lead has but little advantage over a smaller one. With double the weight, there is only an increase of 10 per cent. in the velocity. One of the chief advantages of the large lead is that it is easier to tell when it strikes bottom. In deep and rapid water this is sometimes very difficult.

SUMMARY OF HYDROGRAPHIC WORK.

Number of sections sounded	311
Number of intermediates sounded	163
Number of casts of lead	12,506
Number of angles read	7,681
Number of square miles of hydrography	69¾

ORDINARY LEVELS.

A line of levels was run along each bank of the river. The line on the left bank, checked on the precise benches, and the one on the left bank, checking on the left bank line by means of river crossings once in three miles, if the width of the river would permit. The leveling party consisted of a leveler, two rodmen, and one axman.

Stone lines, or lines not otherwise checked, were always duplicated by using two sets of turning points, changing the height of the instrument and getting two sets of readings, or running over the line twice. These duplicated lines where required to check within 0.1 foot.

The elevations of all triangulation stones, all stones on stone lines, water surface at each sounding flag, and numerous high-water marks were determined. Numerous benches were also established on trees near river banks. A list of level checks and high-water marks is given below:

Discrepancies between precise and ordinary levels.

Between P. B. M's.	Distance.	Discrepancies.	Remarks.
	Miles.	*Feet.*	
Richardson and No 61	¼	—0.167	Run by L. C. Jones.
No. 61 and No. 62	2½	+0.080	Do.
No. 62 and No. 63	11	—0.004	Do.
No. 63 and No. 64	9	+0.029	Do.
No. 64 and No. 65	13¾	—0.036	Do.
No. 65 and No. 66	3	+0.071	Do.
No. 67 and No. 68	5½	+0.070	Do.
No. 68 and No. 70	1½	+0.081	Do.
No. 75 and No. 76	12¼	+0.225	Run by L. C. Jones and S. L. Beaumont.
No. 76 and No. 77	2¾	+0.009	Run by S. L. Beaumont.
No. 77 and No. 78	2¼	—0.006	Do.
No. 78 and No. 79	2	+0.009	Do.
No. 79 and No. 80	3	+0.068	Do.
No. 80 and No. 81	12½	+0.088	Do.
No. 81 and No. 82	2	+0.146	Do.
No. 82 and No. 83	2½	+0.003	Do.
No. 83 and No. 85	5¼	+0.022	Do.
No. 85 and No. 86	1	—0.022	Do.

The algebraic sum of these discrepancies is + 0.366, which would be the error for the total distance of over 100 miles.

Discrepancies between right and left bank ordinary levels.

Locality where compared.	Distance.	Discrepancies.	Remarks.
	Miles.	*Feet.*	
Near Sunflower Landing	4	0.076	
Head of Island 67	7	0.708	Level re-run and error found.
Foot of Island 68	3	0.012	
Near Australia	5½	0.140	
Near Laconia	4	0.320	
Near Concordia	7	0.392	
Foot of Scrub Grass, T. H	8	0.050	
Cumbyville	7	0.387	
Near Prentiss	9	0.177	
Near Buck Ridge	15	1.827	Levels re-run so as to make all bench-marks correct.
Catfish Point	9	0.304	
Eutaw	7	0.020	
Arkansas City	7	0.184	

The above discrepancies include the errors of river crossing. Where the discrepancies were large, enough of the line was always re-run to correct the elevations of benches, as it was impracticable to re-run the entire line to find the error in consequence of the rising river.

Elevation of high-water marks	Year.	Elevation.
Near Sunflower Landing.—On two cottonwood trees near break of bank; water marks very clearly defined; also nails in tree 30 feet from store.	1880	174.7
	1881	173.9
Malone's.—Two nails driven into fourth pillar of Harter's store	1881	173.3
Pushmataha.—Two nails in tree 100 feet from bank and 300 feet north from P. O., 1,000 feet below P. O. Water mark on trees.	1881	171.9
		171.8
Australia.—Marked by nails on sweet gum 300 feet from Lyman's store; also duplicated on sycamore tree 10 feet from the gum tree.	1874	170.3
	1876	170.0
	1880	169.8
	1881	169.2
Concordia.—Nail driven in large cottonwood tree 10 feet from J. W. Williams's store; nail driven in pillar of Williams's store.	1881	166.4
	1880	166.9
Cumbyville.—Referred to gauge	1867	161.3
Terrene —Referred to gauge	1862	163.3
Terrene.—Low water	1872	115.0
Beulah Lake.—Bolt driven into sycamore tree outside of levee and directly in front of the dwelling of Judge Miles; bolt driven at high water of 1862. "The water was 11¾ inches higher than any previous year since the levees were built." The records of Judge Miles also give the following data:	1862	160.6
1858, July 8. Highest water	.....	.....
1859. River low all the year	.....	.....
1860. River low all the year	.....	.....
1861, May 28. One inch higher than 1858	.....	.....
1862, April 20. Highest; levee broken above	.....	.....
1863	1863	157.8
1864. No high water	.....	.....
1865, April 14	1865	159.3
1866, May 14	1866	156.3
1867, May 15	1867	158.8
1868, May 7	1868	157.5
1869, May 6	1869	156.0
1870. No high water	.....	.....
1871, March 26	1871	158.1
1872. Dead low	.....	.....
1873. Dead low	.....	.....
1874, April 29	1874	159.8
1875, April 18	1875	158.3
1876, April 10	1876	160.1
1877, May 5	1877	158.1
1878. River very low	.....	.....
1879. River very low	.....	.....
1880, March 25	1880	159.6
1881, May 16	1881	159.8
Bolivar	1880	155.2
Catfish Point.—Nail in locust tree about one-fourth of a mile above Singer's store	1880	153.05
In floor of porch of Singer's store	1876	153.3
Eutaw—Nail in cottonwood tree about 50 meters from △ Eutaw. Tree is marked 18 ⊙ 80	1880	150.0
Arkansas City.—Opposite Arkansas City, nail in cottonwood tree outside of levee in front of Mr. Shelby's old yard. Tree marked H. W.	1880	147.7

B. M.—For Cumbyville gauge on steps of Mr. Beaman's gallery marked with five tacks thus, ∴. Elevation = 165.109.

B. M.—For gauge at Terrene on Ezell's gate-post of front fence marked with tacks thus, B. M. N. Elevation = 162.776.

Thirty-two-foot mark on gauge at Arkansas City. Elevation = 147.450.

All elevations given refer to Memphis datum plane, which is 225 feet below the 34.16 feet mark in United States Engineer's gauge at Memphis.

RIVER SLOPE.

Stations.	Distance.	Slope per mile.	Rising or falling.	Guage-reading at Arkansas City.	
	Miles.	*Foot.*		*Date.*	*Readings.*
From Sunflower to Pushmataha	7.5	0.23	Stationary	Oct. 17	8.2
From Pushmataha to Dyer's Landing	10	0.3765	Rising	Oct. 24	7.55
From Dyer's Landing to Concordia	8.25	0.283	...do	Nov. 9	11.95
From Concordia to Scrub Grass Bend	7.5	0.47	....do	Nov. 17	15.35
From Scrubb Grass Bend to Cumbyville	9.6	0.306	....do	Nov. 29	23.15
From Cumbyville to Napoleon	8.25	0.294	Falling	Dec. 8	22.15
From Napoleon to point opposite Hayden	9.75	0.272	....do	Dec. 19	*9.85 21.85
From point opposite Hayden to Jersey Point	6.7	0.398	Rising	Dec. 29	**22.4** 34.4
From Jersey Point to Cat Fish Point	5.25	0.354	....do	Jan. 2	**25 25** 37.25
From Cat Fish Point to Eutaw	9.3	0.269	About stationary	Jan. 11	**27.2** 39.2
From Eutaw to point opposite Arkansas City	6	0.283	Rising	Jan. 23	**30.1** 42.1
From point opposite Arkansas City to Port Anderson	5.5	0.327	About stationary	Jan. 24	**30.25** 42.35

*On and after December 18 the recorded readings were 12 feet higher than the actual stage. The figures in heavy type give the true reading.

LEVEES.

At Sunflower Landing the levee runs directly back along a cypress swamp on the north for a distance of 8 miles, where it joins a turnpike running to Friar's Point Going down from the above landing the left bank levee is complete as far as the survey extended. From Sunflower to Pushmataha it is an average of 414 meters back from river. At the latter landing it turns and follows along chute of 68 to foot of same, the average distance from river being 1,350 meters. From foot of 68 to Hurricane Point it averages 313 meters from river. Here it turns again and runs directly to Carson's—mean distance from river, 1,368 meters. From Carson's to Concordia it is about 450 meters from river. At Concordia it turns back along Concordia Bayou, back of Concordia Lake, and comes to river again at Victoria, leaving Smith's Point outside. In the bend below Concordia the levee is about 3,800 meters from river. From Victoria to Waxhaw the levee is an average of 410 meters from the river. At the latter point it turns back and runs almost directly to Rosedale, at an average distance of 1,252 meters back. From Rosedale to Wright's Point it is a mean of 524 meters from the river. At Wright's Point the levee runs directly back, around head of Beulah Lake, following around the lower side of the lake to within 2 miles of Prentiss, when it again turns, and running along inside of Vermillion and Easy Lakes, comes out to the river again at Niblett's. At head of Beulah Lake it is 7,000 meters from river. Patches of the old levee running around Wildwood Point still exist.

From Niblett's it keeps near the river, following around Catfish Point, and on down to Offutt's, where it runs across the neck to Miller's Bend. Between Niblett's and Offutt's it averages 390 meters from river.

The work of raising and strengthening the levee was going on in many places, particularly at Riverton, Beulah Lake, and Catfish Point. This work was going on during the rainy season and the earth put on the levees was soft muck which would almost run off. This may account in a measure for some of the disastrous breaks in the localities named.

On the Arkansas side, beginning about 3 miles above Saint Louis Landing, the levee runs directly across the point to Knowlton's, and then follows along near river down to about three-quarters of a mile above head of Island 67. From that point down to the foot of 67, a distance of 4,300 meters, it has caved into the river. It is then continuous near the river down to Beith's Landing, where it turns back and follows along a slough to Laconia. At Laconia begins the "circle levee," the upper branch running back on lower side of Swan Lake for a distance of 4,800 meters. It then runs about parallel to river for 8,000 meters; then, with a sweeping curve, it reaches a point one-half mile from river at a distance of one mile below Graddy's.

The lower arm follows State levee down to Warfield, about a mile below Laconia, where it runs into river. The circle levee continuing, runs back about 400 meters,

and then almost directly to Henrico, near foot of Island 71. After following river about 400 meters, it turns and runs back 800 meters, and thence along parallel to river to a point of upper branch mentioned above.

From the lower end of the circle levee there are no levees on Arkansas side for a distance of 35 miles, or until Cork's Point is reached, except three small pieces just below mouth of Arkansas River, which are about parallel and run at right angles to river.

From Cork's Point it runs along old river bank down to within a mile of Wilkinson's, where there is a break of 2 miles. It then starts in again, and in a very dilapidated condition runs for 3 miles, where it joins the old Pine Bluff Railroad bed. It follows the railroad down along the river front and the chute of 78 to Arkansas City. Above, at Chicot, a levee leaves the railroad and runs back above Cypress Lake and swamps, and joins the railroad again at Arkansas City, thus really forming a circle levee.

Between Ludlow's, above Saint Louis Landing and Arkansas City, a distance of about 111 miles, there are 38 miles of levee on the Arkansas side. This by counting only the river front levees.

In the reach surveyed the levees are a mean distance from the river of 410 meters, excluding the stretches that run back of lakes, bayous, &c.

CAVING BANKS.

Below is given a list of localities and the rate of caving. The rate is determined from a comparison of the present position of the shore-line with its position when triangulation was done, the shore-line being given in the latter case with reference to △.

Locality.	Character of banks.	Annual rate of caving.
		Meters.
Dyers	Clay and silt	12
Warfield	do	6
Hurricane Point	do	65
Head of Island 71	Clay and sand	40
One mile below Concordia	do	40
Three miles below Concordia	do	30
Scrub Grass Creek	Clay	10
Two miles below Scrub Grass Creek	do	40
Smith's Point	Sandy	20
Waxhaw	Clay and silt	20
One mile below Cumbyville	do	15
Malona	Clay and sand	20
Pride's Point	Sandy	90
Wright's Point	do	20
Arkansas River	Sand	19
Two miles below Prentiss	Clay and silt	10
Williams	Clay and sand	36
Oak Landing	do	235
Hayden	do	5
Cork's Point	do	10
Island 76	Silt	15
Content	Clay and sand	5
Cypress Creek	Clay	10
Chicora	Clay and sand	20
Chicot	do	15
Delolme	Silt	35

It will be observed that the caving at Oak Landing is going on very rapidly, and, as the distance across the neck is only 1,800 meters, there will doubtless be a cut-off at that point, unless changes occur which will divert the current from the bend below Ozark Island. A section of the neck near the narrowest part is shown in section of stone line No. 54.

STONE-LINE SECTIONS.

The sections of all the stone lines from number 36 to 64, inclusive, have been platted for the purpose of comparing the height of the land outside and inside of the levees. In other words, to ascertain whether the land outside of the levees has been built up by deposits so as to be materially higher than the land behind the levee which has been protected from the overflow.

An examination of these sections shows—

1st. The highest land is near the river, usually within 200 meters of it.

2d. The right bank is higher than the left bank by an average of 0.6 foot.

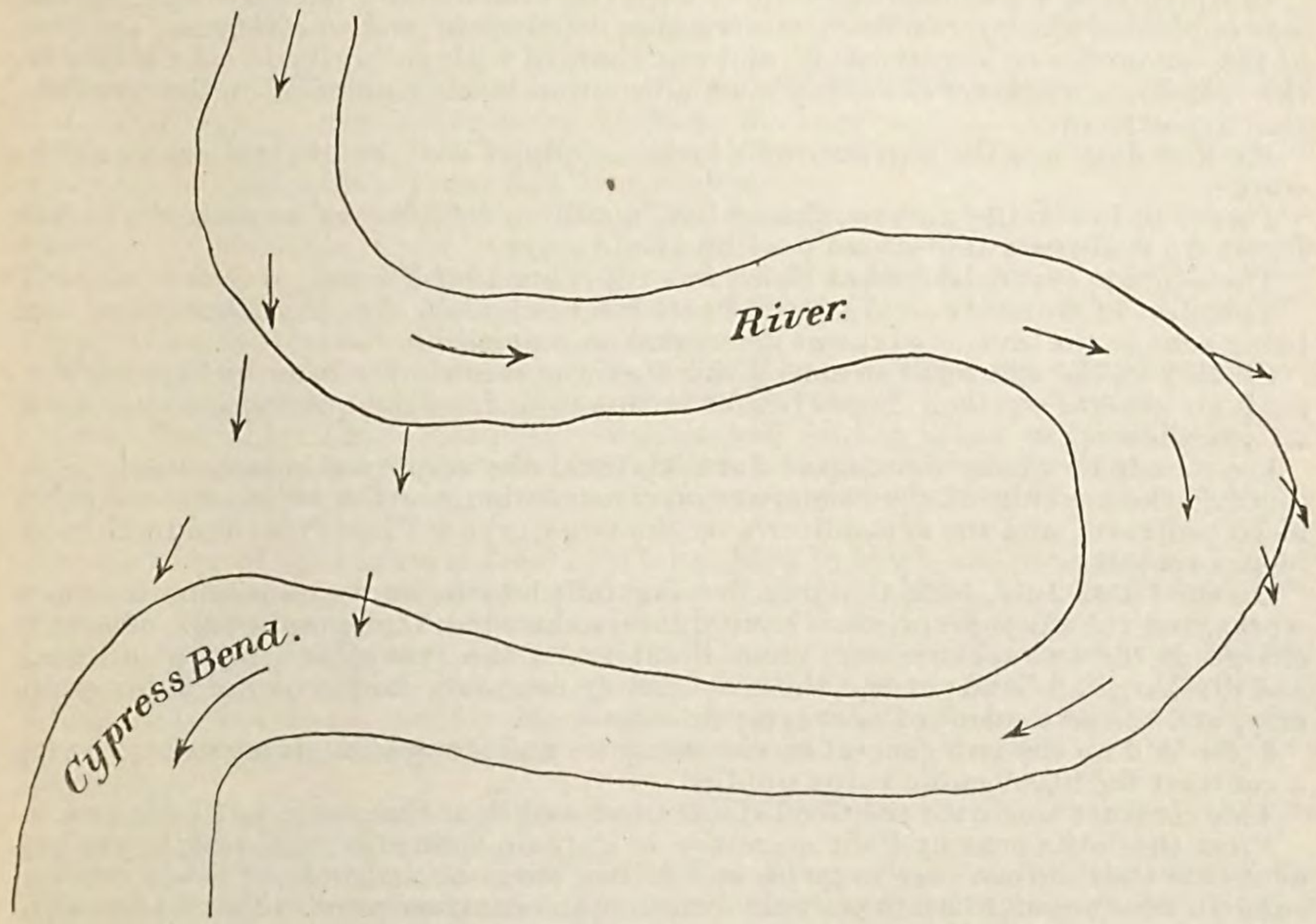
3d. The highest land outside of the levees averages 0.45 foot higher than the highest land inside.

In this comparison we should remember that the levees average a quarter of a mile back, and that the greatest deposit is at the river bank. The results do not indicate that the levees have increased the bank-building process to any great extent.

It is probable that most of the sediment is dropped as soon as the water leaves the river, and but a small proportion would be carried back as far as the levees are. An illustration of this tendency to immediate deposit is shown in the section of Horn Lake Bayou on last page of stone-line sections. The conditions are very similar to the river itself. That is, at an overflow stage it is a silt-bearing stream, flowing with considerable velocity through water, on either side, which is practically still.

An examination of the field plats shows that bars and tow-heads of recent formation are frequently as high and sometimes higher than the main banks adjacent.

In the whole reach of 110 miles there is but one bend where the land on the concave bank is materially lower than the point opposite. This is in Cypress Bend, where the difference amounts to about 4 feet. In general terms it may be said that in bends where the water runs *from* the river into the woods a deposit will be made near the bank of the river, and where the bend is so situated that the overflow runs *into* the river again the bank will receive but little deposit or may even be washed away. In the first case the deposit will, under ordinary circumstances, keep pace with the caving, so that the bank will remain about the same height. The following sketch, which shows by arrows the direction the current actually takes under the conditions mentioned, will serve to illustrate the principle.



During the season work was completed from Saint Louis Landing down to Arkansas City. At that point the high water prevented further work on the Arkansas shore, but on the left bank the topography was completed down to Offutt's. The soundings were extended 3 or 4 miles farther. The survey covered a distance of about 110 miles of river, and a total area of 306 square miles.

The total number of rainy days during the season was 25.

During the last two weeks of the season but little work was done in consequence of the high water and rainy weather.

On the 2d of February orders were received to disband the party, as no further work was practicable. The party was immediately discharged, and the quarter-boats and outfit taken to Duncansby and laid up.

My thanks are due to the assistants, all of whom were faithful and efficient. To their enthusiasm the progress of the work must be largely attributed.

Very respectfully, your obedient servant,

J. A. OCKERSON,
United States Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

APPENDIX H.

REPORT OF CAPT. CLINTON B. SEARS, CORPS OF ENGINEERS, U. S. A., EXECUTIVE OFFICER, DEPARTMENT OF CONSTRUCTION.

DEPARTMENT OF CONSTRUCTION,
Saint Louis, Mo., December 6, 1882.

SIR: In accordance with the resolution lately passed by the Commission, I have the honor to submit herewith the report of operations of my office from the time I was assigned to duty with the Commission up to December 1, 1882.

In April, 1882, I was assigned to duty with the Commission, reported April 24, and was appointed executive officer, construction department, and secretary and assistant of the committee on construction, and was charged with authority to take action for the committee when not in session upon all routine matters relating to the construction department.

My first duty was the purchase of a large supply of coal for general use at all the works.

I went to Louisville and purchased half a million (500,000) of bushels of the best Pittsburg coal (first and second pool) in good barges.

The average cost delivered at Cairo was 10½ cents a bushel net.

This fleet of thirty-two barges and boats has been taken care of at that point, coal being sent to the several works as demanded on requisition.

On May 23 the chartered steamer Etheridge was turned over to me by Captain Marshall for general service. I used her for towing stone from the quarry, and coal, wire, &c., to the works.

The remainder of my time, up to June 30, 1882, was employed in inspection, in attending the meeting of the committee on construction, and the adjustment of unfinished contracts, and the expenditures on the two works at Plum Point and Lake Providence reaches.

On the 1st of July, 1882, Congress having failed to make appropriation for these works, and the old appropriation having been exhausted, I telegraphed the officers in charge of the two reaches, viz, Plum Point and Lake Providence, to stop all work and discharge all hands except those absolutely necessary for the care of public property, and the settlement of accounts; this was done.

I also laid up the two general service steamers and stopped receiving stone, leaving a contract for 10,000 cubic yards unfilled.

This contract was with the Good Hope Lead and Spar Company, at Cincinnati.

From the letter sent by their secretary to Captain Quinn in April last, it was evident that they did not care to go on and deliver stone at the contract prices, but desired an advance of 15 cents per cubic yard on the contract price. This I refused to allow them, and said that I would stop receiving any more stone, my action being based upon this letter.

They afterwards, through their president, expressed their willingness to go on and deliver the remaining 10,000 cubic yards under the contract.

This I agreed to do under certain conditions, viz, that I be allowed to take the stone from time to time as I could supply barges, and that they would take care of our barges while lying at the quarries.

When I came, however, to carry out this agreement, they sent in a bill for the care of the barges.

I paid this bill and immediately notified them that I would take no more stone.

Since then I have been buying stone in open market at 50 cents per cubic yard, which is 15 cents a yard less than we were paying under the contract.

The Davidson steam-pump matter has been satisfactorily settled, the company paying for the expense the United States was put to by their delay in delivering the pumps.

As soon as it was definitely known that the new appropriation bill had become a law, orders were sent to resume work on the Plum Point and Lake Providence reaches.

Great difficulty was experienced in collecting the necessary labor, as the forces previously organized and drilled had been disbanded.

Under the new appropriation the following organization has been made for the administration of the construction department:

An executive officer to take action in the name of the Commission when not in session, upon all routine matters, and to refer important matters to the president of the commission for action.

He is also charged with the responsibility of all floating property belonging to the appropriation, and its transfer from point to point as needed; with the purchase and supply of staple subsistence and material, such as fuel, stone, wire cordage, &c.; with the repair of plant and the construction of new plant. Subsistence supplies are purchased upon bids solicited by circular letters sent to the principal dealers at Saint Louis and other places most accessible for the works.

As far as possible, supplies are carried on in steamers belonging to the appropriation, of which there are two for the general service, though but one has been kept in commission.

New plant is bought on letter contracts after soliciting bids from the principal builders of boats and machinery.

The supplies are issued to the officers in charge of districts upon requisition and in accordance with Army regulations and customs, duplicate invoices and receipts being exchanged.

From Cairo, Ill., to the head of the passes the river is divided into four districts, viz:

First district.—From Cairo to the foot of Island No. 40, headquarters at Cairo; Capt. J. G. D. Knight, Corps of Engineers, U. S. A., in charge.

There are two reaches in this district where work is going on, or where surveys for work are in hand—Plum Point and New Madrid.

Second district.—From the foot of Island No. 40 to the mouth of White River, headquarters at Memphis, Tenn.; Capt. A. M. Miller, Corps of Engineers, U. S. A., in charge. Work is planned in this district for the Memphis Reach, of which surveys are now being made, and Memphis Harbor, where work is being done to the extent of revetting the banks with brush mattresses.

Third district.—From the mouth of the White River to Warrington, headquarters at Vicksburg; Capt. W. L. Marshall, Corps of Engineers, U. S. A., in charge.

Lake Providence Reach lies in this district, and work is going on on this reach.

The other works are at Delta Point, Louisiana, and at Vicksburg Harbor.

That at Delta Point is in progress and contracts are being made for that at Vicksburg Harbor.

The survey of the Choctaw Bend Reach has been ordered, and is in progress.

Fourth district.—From Warrenton to the head of the passes, headquarters at New Orleans; Maj. Amos Stickney, Corps of Engineers, U. S. A., in charge.

This district includes the harbor at New Orleans, where work is planned; Natchez harbor, a survey of which has been ordered; Atchafalaya outlet of the Mississippi River, an estimate and plan for checking the enlargements of which has been ordered; the lock for Bayou Plaquemine, and the rectification of the Red and Atchfalaya Rivers.

No work beyond surveys is yet in progress in this district as far as direct channel nel improvement is concerned.

Each district officer has charge of the repairs of levees lying in his district, and the district officers of the second, third, and fourth districts constitute a permanent board for concerted action upon all matters pertaining to levees.

Under a resolution of the Commission each district officer has been required to make a report of all the operations in his district up to December 1 directly to yourself.

This will obviate the necessity of my reporting any further on the detailed operations in the several districts.

I submit herewith four maps showing the work done up to include the latest report received from the district officers, viz, November 20, 1882.*

I have used for general towing purposes during the season the United States steamer Emma Etheridge. She was purchased by special authority of the hononrable Secretary of War for $19,500, and has been kept in constant use ever since her purchase. She has proved herself a valuable boat.

The iron-hulled steamer Itasca, built for the Commission, has been sent to Plum Point for local use on that reach and has proved an excellent investment.

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* The maps referred to are not printed, being duplicates of maps submitted by district officers.—S. S. L.

By special authority of the Secretary of War the steam tow-boat Pete Kirns was purchased for $11,740. She is also in use on the Plum Point Reach.

For the Lake Providence Reach the steam tow-boats Charlie De Pauw and Success have been chartered for three months, each with the privilege of purchase; purchase price of the former is $20,000, less charter money, paid at the rate of $22 per day; she has proved herself a very excellent boat; the authority for her purchase has been asked. The Success has been chartered at $15 per day, with privilege of purchase for $13,000, less charter money paid; her purchase, however, is not recommended.

The Commission, at its meetings of August 18 and September 14 and 17, recommended the purchase or construction of the following floating plant:

80 decked barges, 100 by 25 by 5 feet, at not to exceed $2,200 each.
2 decked barges, 100 by 25 by 5 feet, at not to exceed $2,000 each.
10 decked barges, 100 by 20 by 4 feet, at not to exceed $1,300 each.
10 decked barges, 100 by 26 by 6 feet, at not to exceed $3,000 each.
Making 102 barges in all.
2 open barges, at not to exceed $1,000 each.
20 pile-drivers, equipped, at not to exceed $5,000 each.
10 pile-drivers, equipped, at not to exceed $4,000 each.
Making 30 pile-drivers in all.
8 quarter boats, at not to exceed $3,500 each.
9 quarter boats, at not to exceed $4,000 each.
1 quarter boat, at not to exceed $2,500.
4 quarter boats, at not to exceed $2,000 each.
1 quarter boat, at not to exceed $1,800.
Making 23 quarter boats in all.
6 mattress boats, at not to exceed $6,000 each.
8 mattress boats, at not to exceed $8,000 each.
10 mattress boats, at not to exceed $2,500 each.
Making 24 mattress boats in all.
10 screen boats, at not to exceed $3,000 each.
4 screen boats, at not to exceed $2,500 each.
4 screen boats, at not to exceed $1,800 each.
Making 18 in all.
2 hull and cargo boxes for quarters, at not to exceed $2,500 each.
90 skiffs, at not to exceed $30 each.
2 derrick boats, at not to exceed $2,500 each.
2 machine-shop boats, at not to exceed $7,000 each.
1 steam tow-boat, at not to exceed $15,000.
2 steam tow-boats to be chartered.

The purchase or construction of the above plant has been formally approved by the honorable Secretary of War, and contracts for its purchase or construction have been made for as much as drawings and specifications have been furnished by the district officers.

The following is a list of said plant as contracted for or already purchased:

102 decked barges.
20 pile-drivers.
2 machine-shop boats.
6 mattress boats.
4 screen boats.
1 hull and cargo box.
56 skiffs.
8 quarter boats.
1 steam tow-boat.

Of this plant, 33 decked barges have been completed and delivered, or are now *en route*.

The hulls and superstructures for 10 pile-drivers are ready, and machinery is being put upon them.

Two machine-shop boats have been completed and delivered.

Six screen boats have been completed and delivered.

Four screen boats have been completed, and one of them delivered.

One hull and cargo box has been purchased.

Twenty-six skiffs have been completed and delivered.

Two quarter boats have been completed and delivered.

Two second-hand barges have been purchased and delivered, upon which to put quarters now on shore.

The steam tow-boat (Pete Kirns) has been purchased, as before mentioned.

With the exception of mattress boats and machine-shop boats, all of the above plant has been contracted for at less than the estimated prices.

The price of the mattress boats was exactly that estimated for.

The machine-shop boats will overrun some $2,000 each.

Special authority for this latter will be asked of the honorable the Secretary of War.

Authority for the purchase of the plant recommended by the Commission at one of its last meetings for the revetment of the Carolina and Louisiana Bends on the Lake Providence reach has been asked for, but not yet received.

I herewith transmit balance sheet showing the itemized accounts of expenditures of the million dollars for the fiscal year ending June 30, 1882.

Also balance sheets showing expenditures by myself as executive officer out of the new appropriation from July 1, 1882, up to December 1, 1882.

These sheets have been itemized as carefully as the state of the accounts on file in my office will permit.

It is presumed that the several district officers will send in with their reports similarly itemized balance sheets for their expenditures to December 1.

I have telegraphed them that such sheets should accompany their reports; the data for said expenditures not having yet been received at my office.

The requisitions made upon me by the various district officers for subsistence materials, and other supplies, have been promptly purchased and shipped, and in general, considering the superior quality of the goods, at lower figures than heretofore paid.

No complaints have been received as yet from district officers as to deficiency in either quantity or quality in the shipments made, nor as to delay in receiving them. When articles are shipped the district officer to whom they are consigned is duly notified, and as soon as possible thereafter is furnished with duplicate invoices and receipts, and the duplicate of the bill or voucher paying for the same, so that he can keep his office informed as to the prices that are paid for the articles.

The following is a statement of the floating plant partially or entirely ready for use July 1, 1882:

	Estimated cost.
34 pile drivers	$170,000
4 hydraulic graders	112,000
80 barges	120,000
15 quarter boats	52,500
6 mattress and screen boats	30,000
41 skiffs	1,025
2 steam tow-boats	70,000
2 steam launches	6,000
Photograph boat	600
	562.125

Two steam tow-boats under charter at $30 and $15 a day, respectively.

Since July 1, 1882, the following floating plant has been authorized by the Commission to be purchased or constructed:

	Estimated cost.
28 pile drivers	$132,000
94 barges	216,000
24 quarter boats	79,800
48 mattress and screen boats	161,200
2 derrick boats	5,000
2 machine-shop boats	14,000
98 skiffs	3,120
4 steam tow-boats	56,240
Total	667,360

Two steam tow-boats chartered at not to exceed $20 a day each.

When this last enumerated shall have been provided, the Commission will have available for use, wherever needed on the river, the following floating plant:

	Estimated cost.
62 pile drivers	$302,000
4 hydraulic graders	112,000
39 quarter boats	132,300
174 barges	336,000
54 mattress and screen boats	191,200
139 skiffs	4,145
2 derrick boats	5,000
2 machine-shop boats	14,000
2 steam launches	6,000
1 photograph boat	600
6 steam tow-boats	126,240
Total	1,229,485

Two steamboats chartered.

Besides the above there has been expended, it is estimated, about $60,000 for mis-

cellaneous portable plant, such as cordage, small tools, bolts, spikes, nails, lumber, paint, &c.

I remain, sir, very respectfully,

CLINTON B. SEARS,
Captain Engineers, U. S. A.,
Executive Officer Construction Department, M. R. C.

First Lieut. SMITH S. LEACH,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

APPENDIX J.

REPORT OF CAPT. J. G. D. KNIGHT, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FIRST DISTRICT, MISSISSIPPI RIVER.

SIR: The following is the report called for by the following instructions:

STEAMER MISSISSIPPI,
Plum Point, November 18, 1882.

CAPTAIN: Pursuant to a resolution of the Commission I have the honor to request that you will prepare for insertion in the next annual report of the Commission a full and complete report of the operations conducted in the district now under your charge. This report should embrace an account of all operations from the date of the last report of the Commission (November 25, 1881) to December 1, proximo, and should be submitted immediately after that day. Such sketches and diagrams as may be desirable to illustrate the report should be prepared in suitable form for reproduction by photolithography and forwarded with, or if possible in advance of, the manuscript. All to be forwarded to the secretary of the Commission, who will place them in the hands of the members engaged in the preparation of the report of the Commission.

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Lieutenant-Colonel of Engineers, and Bvt. Brig. Gen.,
President pro tempore of Commission.

Capt. J. G. D. KNIGHT,
Corps of Engineers, U. S. A.,
In charge of First District Mississippi River, Hotchkiss, Tenn.

The first district, Mississippi River, extending from Cairo, Ill., to the foot of Island 40, a distance of 220 miles, was constituted with the other districts, August 30, 1882; within it, work has been carried on on two reaches, the New Madrid and the Plum Point. The former extends from the head of Island 8 to the foot of Island 14, a distance of 60 miles; the latter from about the head of Island 26 to Randolph, a distance of 38 miles.

NEW MADRID REACH.

The Commission, on August 18, 1882, recommended that a survey, with a view to improvement, be made for this reach at next low-water, and that a project for the plant needed for this reach and for the works of improvement be prepared and submitted. This recommendation was forwarded to me under indorsement of September 8. As it was expected that low-water would occur about the end of November, a survey party was not sent out until September 21. Its field-work is well advanced, and will probably be completed by December 15.

Requisition for the following plant has been made: 20 pile-drivers, 1 machine shop, 6 quarter boats, 16 mattress and screen boats, 40 decked barges, and 40 skiffs. The amount allotted to the improvement of this reach is $700,000. To December 1, 1882, the expenditures for survey party amount to $3,196.75. The following is an estimate sent to the Chief of Engineers, U. S. A., December 1, 1882:

Amount allotted to improvement of this reach		$700,000 00
Already obtained on requisition	$7,500 00	
Applied for for January, 1883	16,000 00	
Cost of plant contracted for, or to be contracted for, project approved	287,400 00	
Possible additions to same	25,000 00	
Labor, subsistence, and material, from February 1 to July 1, 1883	175,000 00	
		510,900 00
Unexpended balance July 1, 1883		189,100 00
Care of property for year following		15,000 00
Balance, which it is thought will be expended November 15, 1883		174,100 00

PLUM POINT REACH.

Until the division of the Mississippi River into districts, the officer in charge of the first district was in charge of works at Plum Point only. Of these works, Capt. J. B. Quinn, Corps of Engineers, U. S. A., was in charge until May 29, 1882. The work here may be considered as covering three periods: the first extending from November 26, 1881, to April 8, 1882; the second, from May 3, 1882, to June 9, 1882; and the third, from August 3, 1882, to December 1, 1882.

First period.—November 26, 1881, the only river improvement work completed was the clearing the river banks of trees, from Ashport to Johnson's Landing and from Fletcher's Landing south 2.5 miles. A survey of part of the reach was under way.

December 31, 1881, the clearing of the banks had been carried as far as contemplated, from 2.5 miles south of Fletcher's Landing (see Plate I) to the head of Osceola Chute, and from the lower end of Bullerton towhead to Craighead Point, and the survey completed. This survey extended from Ashport to Craighead Point, and the resulting map has served as a foundation for Plate I, some changes which have occurred since the survey being indicated thereon.

January 28, 1882, experimental pile-driving on the east side of Bullerton tow-head, near the upper end, had been begun with six pile-drivers furnished by Maj. O. H. Ernst, Corps of Engineers, U. S. A., and was ended by the return of the drivers, February 23, 2,400 feet of dike having been built. The method followed was to sink, with the aid of the hydraulic jet and hammer, two parallel rows of vertical piles, spring the tops together, and fasten them. The line followed was more retired than it would have been had the river been at lower stage.

By April 8, 1882, 540 feet of mattress had been placed at upper end of Bullerton towhead and 2,270 feet of wire netting hung on the piling. At the date of this report this work has about all vanished. The pile dike, by falling of the river, was left above water, and subsequent caving demolished it and also undermining the mattress work, carried bank and work away. The wire screen and mattress well protected the bank behind them during high water; but owing to lack of protection at their base, rapidly disappeared at a lower stage.

The plant, on November 26, 1881, comprised one office boat, embracing office, quarters, machine and carpenter shop and store-room; two quarter-boats, each for 125 men; one survey boat; one set of portable quarters on shore, and sundry brush and stone barges. By April 8, no addition to the completed plant had been made, except one hand wire-net machine and one quarter-boat, though twenty pile-drivers were under contract and ten in process of construction at Plum Point. This latter construction was greatly impeded by the extraordinarily high stage of water, which even covered the banks on which this work had been commenced.

From April 8, 1881, to May 3, 1881, the construction of plant continued, and about the latter date, the beginning of the

Second period, four pile-drivers had been completed and placed in position at the head of Osceola Chute (see Plate II, B). May 13, the 100-foot wire-net machine was, excepting the brush carrier, so far completed as to be placed at work, and in all six drivers were ready; by May 16 a seventh driver was in position, and on June 3 there were eleven ready, of which eight were that day sent to Capt. W. L. Marshall, Corps of Engineers, U. S. A., as the committee on construction, Mississippi River Commission, that day concluded, on account of the extreme high water and consequent accumulation of drift, to stop the present working at Osceola Chute of all but three pile-drivers, and the mattress and screen work. June 9, for stronger reasons, the lack of funds, all work was stopped. During this period there were constructed 4,500 feet of pile dike and 570 feet of foot mattress, 100 feet wide. The method of pile work was to drive inclined piles at first, but as these started out almost as fast as driven, vertical piles were driven and these braced by piles loaded with anchors, each of 1.5 cubic yards of stone in wire netting sunk in the line of the current and attached at the upper ends to the vertical piles. Of this work but about 300 feet remain; by June 11, 1,065 feet had been carried away, due to gaps of 500 and 600 feet remaining unfinished when work was stopped, and to scour along the base. This latter caused the vertical piles to become partly loosened, when the pressure of large bodies of drift was sufficient to carry away piles and braces. The amount of this drift may in part be realized when it is stated that a tow-boat of no small power, the Emma Etheridge, was 2.5 hours in removing one pile-driver from the surrounding mass of drift at the dike. The part of the dike remaining was still sufficient to induce the deposit of considerable silt behind it, forming a bar of some extent and above water at an 8-foot stage. In this report the zero stage is assumed as the low water of 1879. Drift also forced itself against and under the mattress in process of construction, making sinking of it impossible, to a great extent, and destroying most of it. A short piece remains visible at ordinary stage where it starts from the main shore, projecting from a deposit of 6 feet or more of mud. From June 9 to August 3, 1882, work was prac-

tically suspended; some construction of plant being carried on, for which payment was made in subsistence furnished from stores mostly on hand.

Third period.—To the plant on hand June 9 have been added, by December 1, 1882, nineteen pile-drivers, of which four as ordered were sent to Captain Marshall, leaving eighteen now here, one 200-foot wire-net machine and one derrick-boat, all of which were in various stages of construction May 29, and one mattress-boat, one screen-boat, and two quarter-boats, of which one small one is now with the New Madrid survey party. The brush carrier has been attached to the 100-foot wire-net machine, and it is now as shown in Plate VI. For further details relating to this machine, attention is invited to its description furnished by Assistant Engineer A. J. Frith, and hereto annexed. A set of portable quarters for laborers has been temporarily erected on shore, and work on the superstructure of two quarter-boats commenced. Construction work was carried on at

I. Dike at upper entrance to Osceola Chute, Plate II, B, repairs of which were completed, so far as the stage of water would permit, the method being, as shown on Plate II, to brace vertical piles with piles driven at an angle. A foot-mat 3,715 feet long and 75 feet wide has been laid the entire length of the dike, the wire-net machine having been used in its construction. Wattling on the piling has been carried up to the 10-foot stage, willow brush being woven on the piles in bands 15 inches wide and the same distance apart. Additional repairs and further wattling will be made at a higher stage than the present.

II. Center entrance to Osceola Chute, Plate II, B. Here 2,244 feet of pile work have been constructed, the method followed, a section being given at A, Plate II, being to drive two rows of piles, those in each row 7.5 feet apart, the distance between the rows varying with the depth of water; piles in the front row are driven 16 feet below the river bottom, those in the rear row about 11 feet. Joints are secured by three-fourths inch drift bolts, driven without holes having been bored, and No. 8 galvanized-iron wire. The section on Plate II is along a tangent to direction of channel.

III. Dike at upper entrance to Bullerton Chute (see Plate III). This work was commenced September 1, with the hope of turning the channel from Bullerton Chute, where great damage was being done to the Arkansas shore by the river in its restricted channel.

The caving was checked in its progress up-stream, although the main channel is not yet deflected. A deposit is already forming behind this dike, and a channel exists outside of Bullerton, but not sufficiently straight for general use. Piling was carried a distance of 2,117 feet, to a depth of 25 feet of water. Prior to the completion of the foot-mat a portion at the down-stream end was carried away, and has been replaced. The method followed was the same as that last used at the upper entrance to Osceola Chute, but repairs have been made after the method followed at the middle entrance to this chute.

A foot-mat 2,197 feet long and from 70 to 96 feet in width has been sunk along the dike, and wattling carried to the 10-foot level. The method followed in constructing the foot-mat was that used by Major Ernst for the lower mattresses of bank-protection work and described in the Report of the Chief of Engineers for 1881, Part II.

IV. Bullerton tow-head (see Plate III). To hold this the protection of the bank has been commenced, and 1,428 feet of mattress, averaging 107 feet in width, have been constructed and 1,025 feet sunk, the smaller wire-net machine having been used. A pile dike, braced like that at the center of Osceola Bar, has been commenced, 80 feet entirely and 800 partly completed. The direction of this, prolonged, would fall to the westward of the head of the dike on the opposite side of this entrance to Bullerton chute, with the view of intercepting as much of the river, here flowing obliquely to the dike, as possible and still leave a passage-way for vessels.

V. Gold Dust Dike (see Plate IV). Five thousand two hundred and seventy-three feet have been completed; but further pile work on this training wall is suspended by reason of low water. Two mattress-boats are in position preparatory to laying of foot-mat.

VI. Ashport, where, with a view to bank protection, 2,694 feet of mattress, averaging 138 feet in width, have been made and sunk. The necessity of securing pile dikes against scour has caused this work to be discontinued.

SUMMARY.

Pile dike now standing	linear feet..	13,429
Pile dike carried away	do.....	3,900
Mattress in place, 976,835 square feet, or	do.....	10,035
Mattress carried away, 50,000 square feet, or	do.....	500
Screen work, wattling	do.....	5,117

The top of pile dikes was, according to first instructions, carried up to highest water stage. Damage resulting from drift showed the necessity of reducing this, and the 25-foot stage was taken as the level for the top. According to recent instructions, all new work will be carried up to the 15-foot level in the channel, and outside of this to the 25-foot level. The average thickness of mattress work is about eight inches. At least the following work remains to be done on this reach:

BANK PROTECTION.

	Feet
From Ashport to Gold Dust Dike	19,000
From Ashport Bar to Osceola Chute	24,000
Front of Osceola Bar	17,500
Front of Bullerton towhead	8,500
Craighead Point	11,000
Total	80,000

PILE DIKE.

Gold Dust Dike	5,500
Cross-dikes behind this	4,000
Upper entrance to Bullerton Chute	3,000
Lower entrance to Bullerton Chute	5,000
Plum Point to Yankee Bar	13,500
Cross-dikes behind this	7,500
Yankee Bar to Cold Creek	17,500
Total	56,000

FOOT-MAT AND SCREEN WORK.

Along all of above dikes	56,000
Gold Dust Dike, piling now driven	5,273
Center entrance to Osceola Chute	3,500
Upper entrance to Bullerton Chute	3,080
Total	67,853

MONEY STATEMENT.

Amount allotted for improvement of reach		$700,000 00
Expended to December 1, 1882:		
Administration	$3,043 23	
Office expense	1,136 68	
Construction of plant	15,518 58	
Labor on plant	23,551 08	
Labor on construction	25,946 76	
Materials on construction	12,418 67	
Subsistence	16,685 79	
Care of property	7,485 62	
Quarters	6,074 26	
Steamers, towage, &c	6,633 12	
Surveys	871 05	
Medicines	111 21	
Mileage and traveling expenses	68 01	
		119,544 06
Balance, from which expenditures by the executive officer should be deducted		580,455 94

The following is an estimate sent to the Chief of Engineers, U. S. A., December 1, 1882:

Amount allotted to improvement of reach		$700,000
Already obtained on requisition	$150,000	
Requisition for January, 1883	20,000	
Construction of plant—project approved	77,540	
Possible additions to same	20,000	
Labor, subsistence, and material, from February 1 to July 1, 1883	225,000	
		492,540
Balance, July 1, 1883		207,460
Care of property for year following		15,000
Balance, which it is thought will be expended November 15, 1883		192,460

Very respectfully,

JOHN G. D. KNIGHT,
Captain of Engineers.

The SECRETARY MISSISSIPPI RIVER COMMISSION,
2828 *Washington Avenue, Saint Louis, Mo.*

APPENDIX J 1.

[Description of mattress boat, with wire net machine and brush carrier. To accompany report of Capt. JOHN G. D. KNIGHT, Corps of Engineers. See Plate VI.]

A.—Is a 100 by 25-foot barge carrying a platform which runs close to the water.

B.—Is the platform and machine on which is constructed the wire netting, with a mesh 5 feet by a variable width, generally 2 feet, in which the intersections are twisted until they are as strong as the wire itself. This net has double wires (No. 12 and No. 8) running perpendicular to the barge, and single No. 12 wires parallel to it.

C.—Shows the platform with double row of reels of wire feeding the machine.

D.—Is the shaft, carrying motion to the brush carrier; it is supported on the deck, and run by an engine placed centrally in the hold of the barge.

E.—Shows the roof supporting the brush carrier, consisting of a number of chains of malleable iron links, with hooks placed at intervals, and shaped so that when a piece of brush is too heavy it will shed its load. The chain runs over 4—

F.—Sprocket wheels as shown; the chain and wheels are covered by a—

G.—Guard, which prevents the brush from resting on the chain or clogging the wheels; it gradually raises the brush from the hooks, thus avoiding a locking where the chain changes its direction.

H.—An iron way, by which the brush as it passes over is thrown clear to the bottom; it is arranged to allow the netting to pass beneath it.

I.—Is an auxiliary barge carrying boiler, capstans, and lines.

K, L, M.—Show different stages in the construction of the mattress. When brush, as (K), is placed the full width of the barge, and run far enough through mattress to be three feet through the netting, the barge is dropped down stream, until the brush is as shown at M, where brush, just as it is delivered by the carrier, is placed as at L, about 15 feet wide, and the process repeated. This brush is close together, while the binders (K) are about 1 foot apart. It will be noticed that the strain does not come upon them until the barge has been dropped.

N.—The netting forms a base under all, and is delivered the full width of the barge. This mattress when completed is about 12 inches thick.

On the other end of the plate is shown the end view, elevation, and plan of the netting machine, without the reels, to a scale six times as large as the barge.

This mattress has averaged to 1,000 square feet, 5.4 cords of brush; 33 pounds of wire; 2.4 cubic yards of rock; 0.7 bushels of coal, and $6.26 worth of labor, including superintendence, rain, delays, &c. 225 linear feet, 95 feet wide have been made in one day.

ARTHUR J. FRITH,
United States Assistant Engineer.

APPENDIX K.

REPORT OF CAPT. A. M. MILLER, CORPS OF ENGINEERS, UPON OPERATIONS CONDUCTED IN THE SECOND DISTRICT, MISSISSIPPI RIVER.

SIR: In compliance with request contained in letter from the Mississippi River Commission, dated November 19, 1882, I have the honor to make the following report of the operations conducted under the supervision of the Commission, in the second district, from August 2, 1882, to December 1, 1882.

MEMPHIS REACH AND HARBOR.

Preparations were begun towards starting work on the revetment of the harbor on October 1. It was found that considerable repairs would be necessary on the mattress-ways, boats, barges, and men's quartere before the work could be commenced, and this delayed the actual construction of mattresses until about the 20th of October. From that time on the construction of mattresses has been pushed forward vigorously, and up to the present time fourteen mattresses 120 by 60 by 2 feet, and one mattress 120 by 40 by 2 feet, have been completed and sunk. The first two were sunk in front of the cotton sheds and the remainder in front of the coal yards, their position being shown on the accompanying tracing. An examination of the mattresses sunk during previous years was made by a diver, and, with one or two exceptions, they were reported in a fair condition. The necessary repairs, it was estimated, would require about sixteen mats, and these are now nearly completed and, with the excep-

tion of three, are all in place. The brush and poles required for the construction of mattresses were furnished by a party sent up the river about twenty miles; they have cut 211 cords of poles and 1,915 cords of willows. To complete the protection and prevent further caving, the bank above low-water line will be graded to a proper slope and covered with a protection of willow and stone.

Preparations were also made towards beginning the protection of the Hopefield bend with a system of continuous mattresses, in accordance with project dated November 15, 1882, and submitted to the Mississippi River Commission. This work will necessarily be retarded until a suitable plant has been secured. The survey of the reach which extends from the foot of Island No. 40 to Scanlan's Landing has been made, with the exception of a few miles which are yet uncompleted. The shore lines have been accurately determined, the sand bars located, and numerous soundings the whole length of the reach taken. The rate of caving, as determined by comparison with former surveys, has been measured. The field notes have been plotted and maps made.

SURVEY OF THE HELENA REACH.

The survey of this reach, extending from Commerce Cut-off to Friar's Point, a distance of 55 miles, as ordered by the Mississippi River Commission, was inaugurated on October 16. The survey party have completed the work from Commerce Cut-off to foot of Bordeaux Chute, a distance of 16 miles. A system of secondary triangulation was established and connected with former triangulations to test the accuracy of the work. The shore lines and low-water lines were determined and the whole reach of river was frequently sounded. Levels were also run to determine the slope of river and high-water marks. Instructions were also furnished the assistant in charge to locate, whenever practicable, any existing levees on both sides of the river and to note any gaps.

LEVEES IN STATE OF MISSISSIPPI ON YAZOO FRONT.

Four contracts have been awarded in this district toward closing the gaps in the levees. The first was at what is known as "Parker's Enlargement and Breaks," of 100,000 cubic yards. This contract was awarded to McGavock & Tate, at 32 cents per cubic yard.

The second, at Lake Charles Break, 30,000 cubic yards, to J. W. Eldridge, at 25 cents per cubic yard.

The third, at Garth's Break to Jefferson's, 95,000 cubic yards, to Timothy Sullivan, at 22 cents per cubic yard.

The fourth, at Bland's Bayou to Garland's, 66,500 cubic yards, to Arnold & Co., at 24¾ cents per cubic yard.

The levees have all been staked out and the contractors are pushing the construction rapidly forward. Estimates have as yet been received only from Lake Charles Break, where the clearing and muck-ditching have been completed and 12,582 cubic yards of embankment placed.

On the Jefferson Break the surface-breaking and muck-ditching is very nearly completed.

SURVEY OF THE SAINT FRANCIS FRONT.

The survey of this front, as ordered by the Mississippi River Commission, and extending in this district from Helena to foot of Island No. 40, was begun by two parties, in order to push the survey forward as rapidly as possible, each party beginning at one end and working towards each other. After their being in the field, however, for a couple of weeks they were called in, owing to the bad weather and the small amount of funds allotted by the Commission to make the complete survey. The levees will be traced in the office from maps, and all existing breaks will be located, and a party will then be sent out to measure them. All the works have been considerably retarded by bad weather, and in very few instances by sickness among the men.

The surveys of the Memphis and Helena reaches will be completed as soon as possible, as well as the survey of the Saint Francis front.

The construction work on the Memphis reach will be carried on as long as the stage of water will permit; and the gaps in the levees will be closed as much as the funds available will allow.

Very respectfully, your obedient servant,

A. M. MILLER,
Captain Corps of Engineers.

Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission,
No. 2828 Washington Avenue,
Saint Louis, Mo.

MEMPHIS REACH AND HARBOR.

Aug. 2, 1882.	Improving Mississippi River, allotment for Memphis Reach and Harbor	$325,000 00
Dec. 1, 1882.	To amount expended for—	
	Labor	7,518 69
	Material	1,138 15
	Supplies	75 86
	Repairs	145 90
	Outfit	181 05
	Assistant engineer	1,010 00
	Clerk	125 00
	Stationery	14 14
	Traveling expenses	134 94
	Subsistence	2,334 50
	Hire of tug and barges	1,319 00
Dec. 1, 1882.	To amount expended from August 2 to December 1	13,997 21
	Balance on hand	311,002 79
		325,000 00

A. M. MILLER,
Captain, Corps of Engineers.

CONSTRUCTION AND REPAIR OF LEVEES—YAZOO FRONT.

Aug. 2, 1882.	Improving Mississippi River, allotment for construction and repair of levees—Yazoo front	$80,950 00
Dec. 1, 1882.	To amount expended for—	
	Labor	211 00
	Outfit	2 10
	Assistant engineer	550 00
	Stationery	14 90
	Traveling expenses	75 00
	Telegrams	50 41
	Advertising and printing	220 06
	Levee work on Lake Charles break*	4,147 02
Dec. 1, 1882.	To amount expended from August 2 to December 1	5,270 49
	Balance on hand	75,679 51
		80,950 00

A. M. MILLER,
Captain, Corps of Engineers.

SURVEY OF THE HELENA REACH.

Aug. 2, 1882.	Improving Mississippi River, allotment for survey of the Helena Reach	$8,000 00
Dec. 1, 1882.	To amount expended for—	
	Labor	1,079 99
	Supplies	139 05
	Repairs	6 00
	Outfit	574 92
	Assistant engineer	300 00
	Subsistence	235 96
Dec. 1, 1882.	To amount expended from August 2 to December 1	2,335 92
	Balance on hand	5,664 08
		8,000 00

A. M. MILLER,
Captain, Corps of Engineers.

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*10 per cent., or $460.78, has been withheld on this payment.

SURVEY OF THE SAINT FRANCIS FRONT.

Aug. 2, 1882.	Improving Mississippi River, allotment for survey of the Saint Francis front	$4,000 00
Dec. 1, 1882.	To amount expended for—	
	Labor	570 83
	Supplies	24 85
	Outfit	617 27
	Assistant engineer	330 00
	Towage	20 00
	Hire of team	100 00
	Transportation	60 10
	Traveling expenses	79 95
	Subsistence	282 46
Dec. 1, 1882.	To amount expended from August 2 to December 1	2,085 46
	Balance on hand	1,914 54
		4,000 00

A. M. MILLER,
Captain, Corps of Engineers.

APPENDIX L.

REPORT OF CAPT. W. L. MARSHALL, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT, MISSISSIPPI RIVER.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., December 1, 1882.

SIR: The following report of operations for the works in my charge, from the date of the last annual report of the Commission up to December 1, 1882, is respectfully submitted.

W. L. MARSHALL,
Captain of Engineers.

Lieut. SMITH S. LEACH,
Corps of Engineers, U. S. A., Secretary Mississippi River Commission.

1.—LAKE PROVIDENCE REACH.

The project for the improvement of this reach consists in a reduction of the wide reaches, by contraction works of piling and brush constructions, to an approximately uniform width of 3,000 feet; the revetment of the Carolina and Louisiana or Bunch's Bend; the revetment of Island 93 and head of Stack Island, and of the Louisiana shore from Vista to Deesona, and at Point Lookout.

At the date of the last annual report the survey party was in the field making a survey of the reach upon which to base a project for its improvement, and the collection of plant at the works has begun.

This survey was completed about January 1, 1882, and a project submitted to the construction committee January 12, 1882. Meanwhile the river had risen to the top of the banks, which put an end to all hopes of accomplishing any material amount of work of improvement. The attention of the officer in charge was then directed to the work of preparation of plant for the next low-water season, cutting and rafting piles, and experimenting in driving piles on the bars at Baleshed and Duncansby towheads with drivers loaned by Capt. O. H. Ernst, Corps of Engineers.

About 6,000 linear feet of pile dike, consisting mainly of a single row, were driven on lines selected by the construction committee, and which, though not completed, withstood the unprecedented flood of the past year, with the loss of a few piles only, at the head of Baleshed Bar, and by the effect of pile dikes and currents each upon the other, taught lessons which more than repaid their cost.

The high water remained at within five feet of the extreme flood stage from January until July, or for six months, culminating March, 1882, during which interval the work performed was as follows:

Maps of the survey of the entire reach from Carolina Landing to the foot of Island 95 were constructed. Resurveys were made in February and April, to exhibit the tendency of changes going on in the river, and numerous special surveys, maps of which have been forwarded.

The surveys cover 35 miles of river. The banks were cleared in caving bends of timber for an average width of 120 yards for 23½ miles, 7,410 piles were cut, and 2,340 of them rafted; 1,827 piles were driven in water varying between 4 and 34 feet in depth, all of which, with the exception of a few at the head of Baleshed Bar, which were carried away by drift, &c., are still in place. Five hundred and eighty-six feet of foot-mats and screens were placed, 9,634 running feet of piling driven—of which 2,829 feet were driven on Baleshed Bar—and 6,805 linear feet between the two tow-heads in front of Duncansby.

On July 1 work was suspended for lack of funds, and not resumed until August 14, 1882, under the river and harbor bill of August 2, 1882. Pile-driving was then resumed with five drivers, and has been continued without intermission since, increasing the number of drivers to twelve.

The river had fallen and left exposed miles of swamp filled with decaying fish and vegetable matter. The resulting malaria almost put an end to work during the months of August, September, and October. I know of but few whites on the river who were exempt from chills and fever and bilious disorders. It was found impossible to maintain an efficient working force. The negroes, who alone could stand the climate, left for the cotton fields, and the few whites on the work were two-thirds the time unfit for duty. For these reasons it was not practicable to begin the work of bank protection with any effective force until towards the middle of October, nor to fill to effective strength the brush-cutting and screen parties.

At present the work is progressing favorably with about 500 laborers employed. We can employ 2,000 to advantage.

One mattress party only has so far been employed; these parties will be increased as fast as labor can be had.

Up to date the following is the sum total of work performed:

Of piling, 23,284 linear feet, of which 4,289 feet consists of a single row of piles and 18,995 feet consists of a double row of piles; of which 14,292 feet have been braced with cross-braces and 12,626 feet with horizontal string pieces in addition; this bracing will be described further on.

5,375 feet of screens have been built.

7,379 feet of foot-mats, 30 feet wide.

395 feet of hurdle-wattling.

1,719 linear feet of bank revetment has been completed below the low-water mark.

No grading or upper bank protection has yet been done on the reach for lack of labor, or rather of quarters for laborers.

In addition a great deal of work in the way of construction of plant has been performed, viz:

4 pile-drivers, with quarters each for 12 men.

1 experimental driver (since dismantled).

7 sets of quarters on barges purchased.

1 set of cranes for lowering floating screens.

2 derricks, 1 machine shop, 12 skiffs.

A number of small flats for screens.

6 cars for tramway; 4 sets mattress-ways.

1 set quarters on shore, and 12 drivers remodeled to drive vertical piles in the deep water of this reach.

METHODS OF CONSTRUCTION.

The pile dikes constructed in this reach are of two classes: First, longitudinal dikes for defining the width of the regularized river, and for guiding or training dikes approximately parallel to the current, and cross-dikes on lines perpendicular to the direction of the currents to retard velocities parallel to the banks.

The construction of the two, as far as piling is concerned, is identical. Two rows of piles are driven, 8 feet apart between centers in each row, the two rows being 10 to 12 feet apart, and the corresponding piles of the two rows exactly opposite each other. The tops of the piling are limited to the 15-foot stage of water, or at higher stages kept as low as practicable, in order to escape drift. When the water surface is 6 feet and not over 10 feet below this stage, horizontal cross-braces are placed at the water line from the back to the front row (AD, Fig. 1), spiked and wired to the piles at A and D, spiked at the intersections with 10 by ½-inch spikes, and bound diagonally with No. 8 wire. At B two 8-inch spikes are driven into the rear pile to within 1 inch of the heads, and No. 8 wire wound over the spikes at D and below the shoulder at A and twisted tight by the rack-stick C. Four or eight strands of wire are used, making a rope when twisted about five-eighths of an inch in diameter, of the ultimate strength of 9,400 pounds. To yield to pressure in the direction of the arrow the rope AB, or the rear pile, must break, or the front pile pull out of the ground. The system is rigid. Continuous horizontal string or waling pieces or poles are then spiked longitudinally, shown in section at A and D. When the water level is near or above the 15-

foot stage the brace is of the same form, the tie being a five-eighths-inch iron rod, bound with wire at A to the front pile, and hooked into four strands of No. 8 wire over the shoulder at B, twisted tight by rack-stick c, Fig. 2.

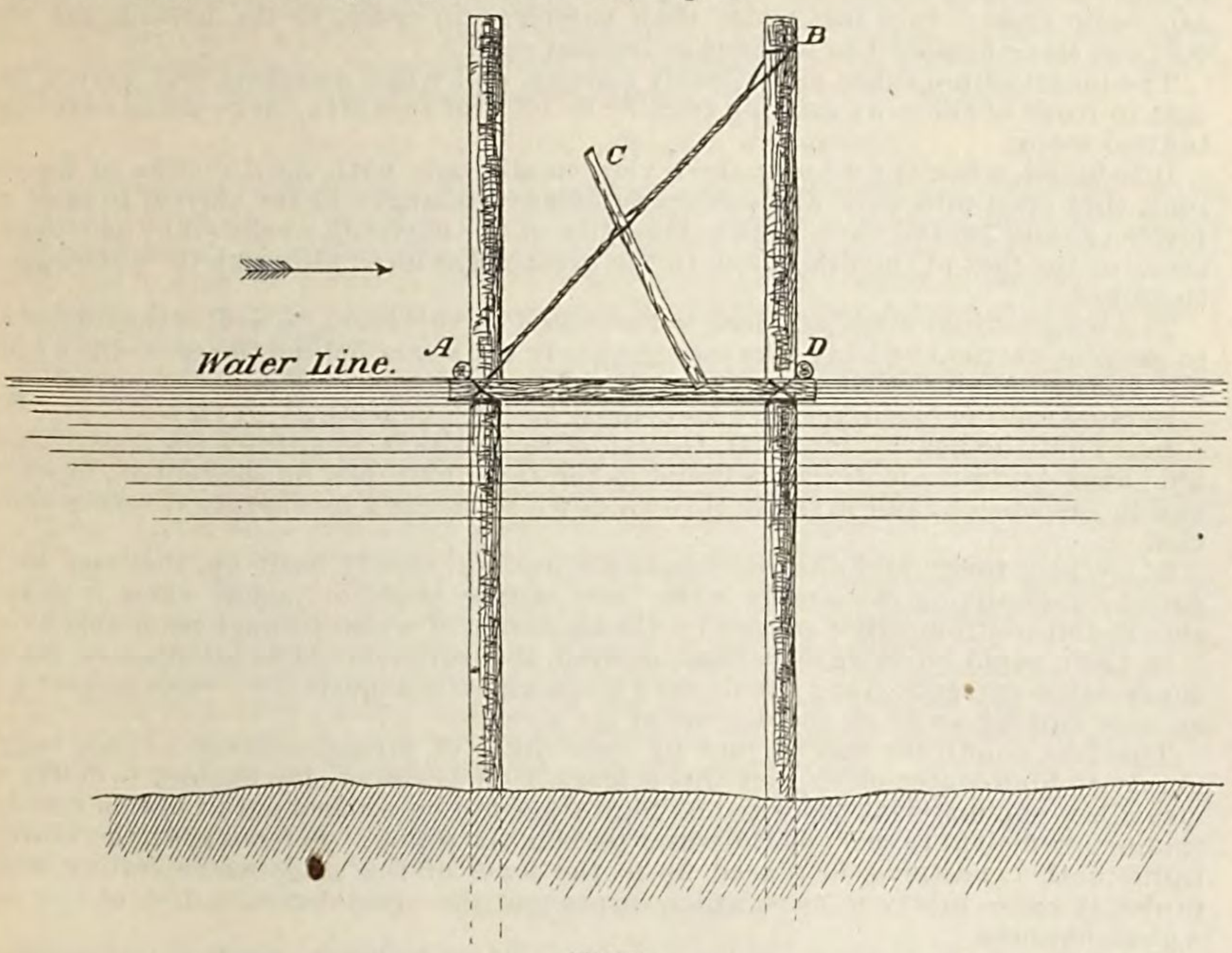


FIG. 1.

Having cross-braced the piles, brush mats 30 feet wide are made, floating on the water between the two rows, and projecting from 10 to 15 feet beyond them, and sup-

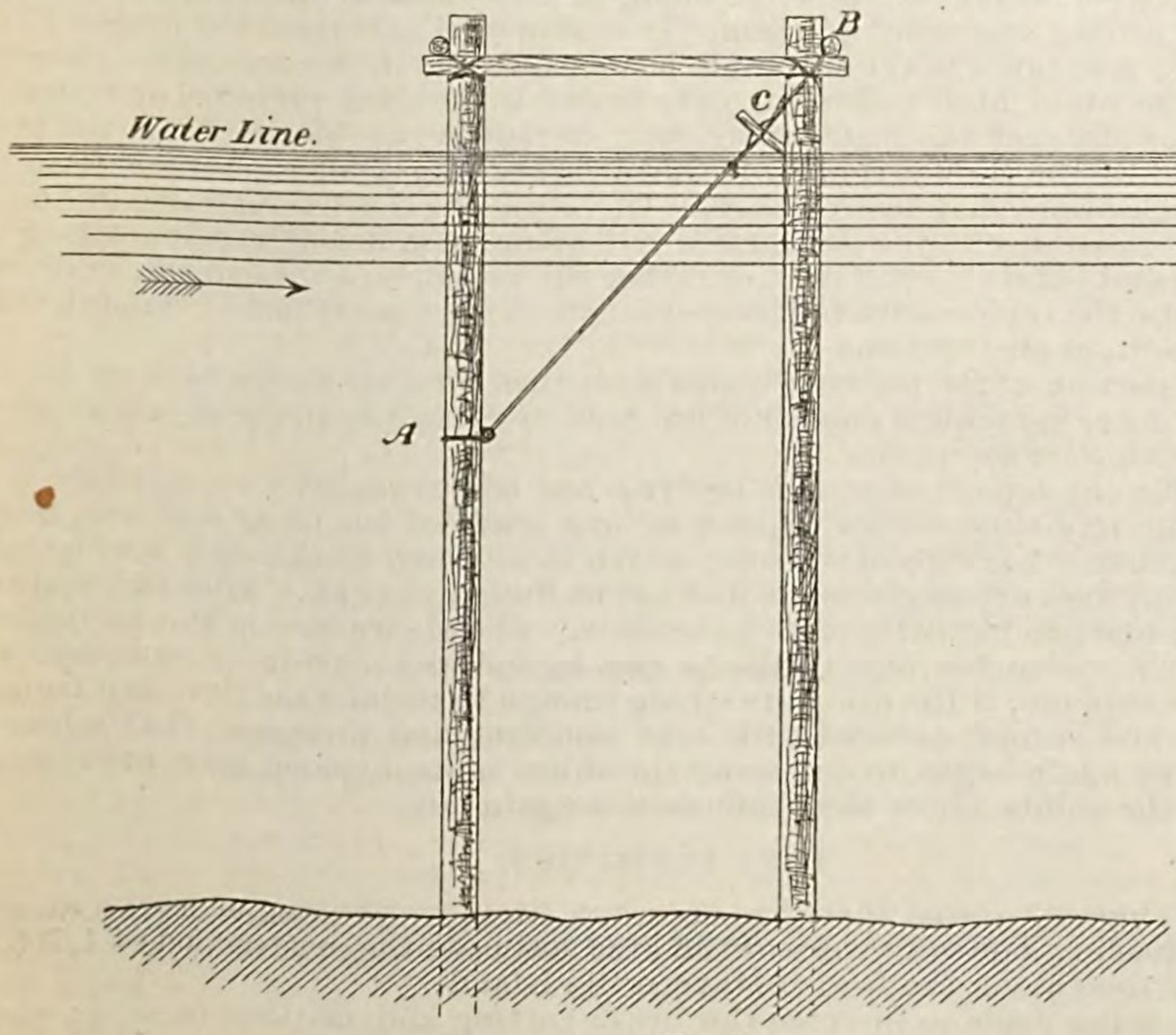


FIG. 2.

ported by the piles, until ready to sink, with twine or wire binders. Stone is loaded upon the mats, and they are allowed to slide down the piles to the bottom.

On the cross-dikes screens with about 75 per cent. openings are then suspended; these screens are hurdle-work of poles and brush, the brush horizontal; at the upper end of each hurdle is a double string piece bolted and wired to the piling. The screens are made from 4 to 8 feet wider than sufficient to reach to the bottom, and sunk without stone attached in sections of 100 feet each.

The longitudinal dikes are without screens, and when complete will have a foot-mat in front of the rows ranging from 50 to 100 feet in width, to guard against longitudinal scour.

It is found, when the dikes make a very small angle with the direction of the current, that open pile work alone offers sufficient resistance to the current to cause deposits of sand behind them, and a deflection of the currents, as shown by longitudinal scour at the foot of the dikes, due to the centrifugal force piling up the water against the dikes.

The longitudinal dikes are used not so much on this reach to deflect the currents as to prevent vertical or eddy-like movements in the water behind the cross-dikes which rest one end against them.

In constructing the dikes, two facts must be kept constantly in view:

1st. That the heavier material, the white sand which constitutes the mass of available bank-building material, is found in the rapid currents, on the bottom, in waves, and in suspension, and is easily thrown down or stopped by sharply checking velocities.

2d. Where tough and durable banks are desired, slowly built up, they may be secured by admitting the muddy water into silting pools or ponds, where it may be slowly and continuously replaced by the admission of water through permeable works.

If, then, rapid building of banks is desired, the works should be so built as to sharply check rapid currents along the desired lines, and the deposit thus made be protected against cutting away on the decline of the river.

The first condition may be met by open dikes of piling, without screens, carried nearly to high-water mark, but this construction, besides being exposed to drift, will also allow the material deposited at high stages to be washed out at low, or cut into channels sufficient to carry off the water passing the piling. Screens must, therefore, to fulfill both conditions, be placed up to the level of the stage where cutting would probably cause injury to navigation, or prevent the rapid determination of the low-water channels.

To fulfil as far as practicable the conditions of works for the gradual contraction of the river channel and improvement of the low-water navigation, the tops of dikes constructed in this reach are kept down as far as practicable to the level of the 15-foot stage—the oscillation of the river being 39 feet—and screens with from 60 to 75 per cent. of opening suspended to them. It is supposed that these low dikes will not offer sufficient resistance to the current to be torn out, and at the same time will retard sufficiently the rapid high-water currents to catch the sand projected or rolled between them or obstruct the water sufficiently to reduce its velocity below the point at which sand can be transported by it, and at lower stages determine the cutting out of channels elsewhere than behind them. Of course, as the bar increases in height, the frictional resistance of the bar formed will alone be sufficient to reduce the velocity of the current before it reaches it, or rather the presence of the bar will, by deflecting them, cause the rapid currents transporting heavy sediment to flow through channels more free from obstructions.

The upper portion of the restored banks must then be more slowly built up by silting works proper, inducing a deposit of fine mud by retarding an already slow current laden only with finer sediment.

After a sufficient deposit of sand is secured, our efforts should then be made to secure above the mid-stage a thin deposit of fine mud, which holds sufficient humus to afford sustenance to crops of willows, which in all cases immediately spring up on bars where this finer deposit is made, and not on fine sand at all. After the willow is started there remains but little more to be done. The obstruction of the currents by the willows will cause the new banks to rise by induced deposits of mud, and it is reasonable to suppose, if the dikes are strong enough to reclaim the river bed from the channel-way and become covered with mud and sand and preserved, that when the restored banks again begin to cut away the dikes again exposed may prevent cutting beyond the points where their influence is again felt.

BANK PROTECTION.

For reasons already stated there has been but little mattressing of banks at Lake Providence Reach. The only work of the kind has been the construction of 1,700 feet of hurdle-mattress along the face of Mayersville Island.

Efforts are being made to increase the brush-cutting and mattress force, to enable us to protect the bank above the mattress that has been laid.

The island is mainly of sand, and the work will not stand unless the face is completely protected. The holding the present face of this island is the most important

work on the reach, as it influences the entire channel below it. It will be difficult to prosecute the work of improving the channel of the river by the methods adopted here at reasonable expense unless material, such as brush, stone, and piles, can be obtained as rapidly as needed by contract. So far our efforts to get such material in this way have been marked by very distinguished lack of success. There is no energy in the Mississippi Valley near the works, no inclination to take contracts that require labor to execute, or to fulfil engagements entered into of that character.

EFFECTS OF WORK ALREADY EXECUTED.

The only works on the reach approximating completion are the dikes and silting works at Skipwith. The dikes shown upon the map herewith, of the April survey, 1882, were driven at high water, and were left without screens. The effect of these dikes was to cause a heavy deposit of white sand behind them, connecting the two tow-heads, and entirely excluding the water between them at 12 feet above low water, or a fill of from 6 to 18 feet.

The bar at the head of the upper tow-head, however (as shown on the December, 1881 survey), extended for about 2 miles up the river and acted as a retaining dike to guide the water into the Skipwith Chute; this chute was cutting out rapidly, and without doubt a low-water channel would have been determined through the chute had it not been that the two lower cross-dikes were rapidly built and screens hung to them in August while the water was still too deep to close the head of the chute. The water thus being prevented from passing behind the islands, in two days cut a channel at the head of the tow-head, where there was but 3 feet of water, 200 feet wide and 22 feet in depth, and the chute began to fill up. Three additional cross-dikes were then built, as shown on the map; screens were hung to them, and the entire mass of water, full one-half the capacity of the river, diverted over the crest of the bar, cutting it into numerous channels, some of which are already deep low-water chutes. The entire chute now as far down as Skipwith is, as shown, dry at low water. The effect of these works is all that could be desired, and if they can withstand the next high water an area of about 2½ square miles will be reclaimed from the channel of the Mississippi at this point, and the river for about 4 miles of its course contracted to the limits proposed by the Commission.

GENERAL REMARKS.

We are now, or will soon be, provided with plant of all kinds for vigorously prosecuting the work.

The pile-drivers, which are all combined jet and hammer drivers, have been improved until they are quite satisfactory. The hydraulic grading engines, as may be seen from the report upon Vicksburg Harbor, have reduced the cost of grading banks to within 3 cents a cubic yard, which will no doubt be further reduced as experience is gained. The mattress-boats, barges, and quarter-boats are nearly all on hand, and we may now hope to make rapid and effective progress if malarial diseases do not continue to prevent a sufficiency of labor, or high water put an end to our efforts. Well-studied methods of construction have been adopted, complete in all details, and the corps of assistants are becoming familiarized with them. The experience of the next high water will reveal the weaknesses of the system, and, having remedied them, there is but little doubt but that the river at this reach can be controlled, at least so far as the interests of navigation are concerned.

The inauguration of a work of this magnitude of an experimental character, and requiring such a large floating plant, is necessarily expensive, but the materials and expense of construction, once having provided the boats and tools, are not excessively costly, nor the methods too slow of application.

Delays in the inception of the work have necessarily attended inexperience and lack of previous experiment in controlling such streams as the Lower Mississippi. The conndditions were all entirely new and untried, but a better understanding of the dangers and difficulties to be encountered is rapidly suggesting remedies.

FINANCIAL STATEMENT.

Under act of March 3, 1881.

Expended for plant	$208,844 93
Expended for coal and wire	69,629 42
Expended for services	32,858 10
Expended for tow-boat service	22,363 18
Expended for subsistence	8,187 43
Expended for office supplies, current repairs, transportation, landing charges, &c	6,780 64
Total up to July 1, 1882	348,663 70
Balance on hand available July 1, 1882	000,000 00

2. *Under allotment from appropriation act of August 2, 1882.*

Expended for plant and tools	$23,068 48
Expended for coal and piles	3,873 15
Expended for services	46,061 80
Expended for tow-boat service	5,492 03
Expended for subsistence	6,968 33
Expended for miscellaneous	1,611 44
Total expended	87,075 23
Balance available	562,924 77
Amount allotted for Lake Providence	650,000 00

IMPRROVING MISSISSIPPI RIVER AND HARBOR OF VICKSBURG.

This work was turned over to me by Capt. A. M. Miller, Corps of Engineers, September 18, 1882, and preparations immediately commenced for continuing the revetment at Delta Point.

Additional barges were borrowed from the work at Lake Providence, a set of quarters for a brush party built, laborers employed, and the work rapidly and successfully pressed up to date. One thousand one hundred linear feet of bank has been graded and revetted, both above and below the low-water line, leaving an equal amount of work yet to be done. The revetment consists of closely-woven hurdle-mattresses, sunk in the longest maneageable sections (generally about 300 feet long). Piles are driven through the subaqueous revetment to prevent sliding. The upper bank is then graded to a slope of 2¼ to 1, which is the same as the under-water slope, and revetted with 10 inches of brush, to be covered afterward with 1 foot of stone. The mattress so far built has extended from the bottom of the river to the top of the bank.

The bank was for a time graded by hand, but afterwards one of the graders belonging to the works under the Mississippi River Commission was borrowed, and is making very rapid progress. The bank, though of varying hardness, is succesfully graded, and rapid improvement in results as the men become trained is apparent. This machine for the first ten days' service excavated only 600 cubic yards per day, the next ten days 700 only, the third 1,300; it then attained in three days 4,200 cubic yards, and is now, December 3, excavating nearly 2,000 cubic yards per day of eight working hours, and at an expense of about 2½ cents per cubic yard. Under favorable conditions, with trained crews, it is hoped to reduce the cost of bank-grading to less than 2 cents per cubic yard.

At present it does daily the work of 400 men, with the crew of 12 men, and at a saving of about $300 per day, and an immense saving in time. It should be furnished with electric lights, and be run day and night in three watches; they would then repay their cost ($28,000) in six weeks.

Four of these machines have been built, but so far this one only has been used.

The main parts of the machine consist in—

One duplex compound condensing pump, 2,000 gallons capacity per minute, under 140 pounds pump pressure; 3 steel boilers, 40 horse-power each, 60,000 pounds T. S., platform and discharge boom-pipe 65 feet long, the latter being fitted with nine 4-inch discharge openings and valves for hose connection.

The boom-pipe and platform are intended to lead the water to the bank slopes and for convenience of service.

The boat itself is 130 by 30 by 6 feet hold, and provided with sleeping accommodations for thirty men and two foremen.

The report of Assistant Engineer H. St. L. Coppée and maps herewith will explain the work.

FINANCIAL STATEMENT.

Balance of appropriation under act March 3, 1881	$25,770 13
Allotment from appropriation for improving Mississippi River	50,000 00
Total	75,770 13
Expended to date, as shown below, December 1	28,012 30
Balance available December 1	47,757 83
Expended for plant and tools	4,293 63
Expended for stone and coal	327 35
Expended for service	15,062 46
Expended for tow-boat service	1,915 25
Expended for subsistence	5,992 73
Expended for miscellaneous	420 88
Total	28,012 30

DREDGING THE HARBOR OF VICKSBURG.

Under an allotment of $100,000 for dredging the canal and basin in front of the city wharves, in accordance with the project approved by the Mississippi River Commission September 18, 1882, the work was advertised and sealed proposals opened November 30, 1882. The abstract of the bids received is given below.

Abstract of proposals for dredging Vicksburg Harbor.

Name of bidders.	Residence.	Date of completion.	Price per cubic yard.	No. of dredges.	No. of scows.	No. of tugs.	Daily capacity.
		1883.					*Cub. yds.*
1. Geo. C. Fobes & Co. ..	Baltimore, Md..	June 30	19 cents for dredging.....	1	2	1	4,000
2. A. J. Whitney	Keokuk, Iowa ..	Sept. 30	$21\frac{3}{4}$ cents for dredging and dry excavation.	2	4	1	2,000
3. B. S. Wood, jr	Pittsburg, Pa ...	Sept. 30	37 cents for dry excavation..	1	2	1	600
4. Chas. H. Appleton	Quincy, Ill.....	Sept. 30	$33\frac{1}{3}$ cents for dredging.....	1	2	1	From 600 to 800.
5. Joseph Cummings	New York, N. Y.	Sept. 30	35 cents for dredging and dry excavation.	1	2	1	1,500*
6. S. N. Kimball.....	Mobile, Ala	Sept. 30	$18\frac{3}{4}$ cents for dredging and dry excavation.	1	2	1	.....
7. Ritterhouse Moore....	Mobile, Ala	Sept. 30	$12\frac{1}{10}$ cents for dredging and dry excavation.	1	2	1	4,000

* With each machine.

No action or recommendation has yet been made, as the officer in charge is investigating the facilities possessed by the bidders for promptly executing their contracts.

The amount of the allotment, after calculating the amount of dredging, was found insufficient to accomplish any amelioration of the condition of the harbor if applied to excavating the entire length of the canal down to a uniform level throughout, as approved by the Commission September 18, 1882. Consequently, at my request, the project has been modified so far as to allow the dredging under the present allotment to be confined to the keeping open the west entrance to the lake and the dredging out an approach to the steamboat landing, 150 feet wide, and the basin, 300 feet by 1,500 feet, in front of the elevator, both to the low-water mark.

The filling at the west entrance to the lake and at the mouth of the proposed canal is so rapid that dredging operations alone will have to be continuous to maintain a sufficient harbor at Vicksburg, unless some force capable of keeping the artificial channel scoured out is introduced. This accessory may be found to some extent in the current of the Yazoo, which, however, is incapable of keeping its own mouth clean, the diversion of which will cost, it has been estimated, nearly $2,000,000 in addition to the cost of dredging the harbor. The estimated cost of dredging a canal of the restricted limits proposed down to an 8-foot low-water channel is $400,000. The annual amount of dredging required thereafter, at present rate of fill from the river, will be about 62,000 cubic yards to maintain the canal.

There is, however, a very important element of deterioration which has not heretofore been taken into consideration in discussing the sedimentary deposits in the artificial canal proposed and in the lake behind it, viz, the wash from the Vicksburg hills, and especially that brought into the lake by Bayou Glass; the latter deposit already is dry nearly half way across the lake at an 8-foot stage, or has filled the deep bed of the Mississippi to that extent since the cut-off.

FINANCIAL STATEMENT.

Amount alloted for dredging in Vicksburg Harbor.....	$100,000 00
Amount available	100,000 00

SURVEY OF CHOCTAW BEND REACH.

Under an allotment made by the Mississippi River Commission September 18, 1882, a party has been fitted out for the survey of the reach from Cork's Point to Arkansas City. The party, consisting in all of twenty-two men, under charge of Assistant Engineer William T. Blunt, took the field November 16, 1882. Up to date no full report of progress has been received. As only a hydrographic survey is required it will probably be completed by January 15, 1883, when a project for the improvement of the reach will be prepared.

FINANCIAL STATEMENT.

Expended for team hire	$7 00
Expended for twine	55
Expended for oil	50
Expended for stovepipe	12 00
Expended for lumber	12 50
Expended for nails, anchors, &c	66 75
Expended for services	499 17
Expended for subsistence	6 25
	604 72
Allotment from appropriation for improving Mississippi River	4,000 00
Expended to date, as above, December 1, 1882	604 72
Amount available	3,395 28

LEVEES.

The Board of Engineers convened at Memphis, Tenn., September 14, 1882, with th- approval of the Secretary of War, awarded the following contracts for the construc- tion and repairs of levees in the district under my charge. This list includes all fill- ing of gaps and repairs necessary on the Mississippi side to restore the levees to the grades prior to the flood of 1882, and on the Tensas front from the lower end of the district to the Ashton Crevasse in Louisiana. From this point to Luna Landing, Arkansas, the levees are practically destroyed and left down for want of means.

The two levees, Duffin's Break and Panther Forest levee, Arkansas, were awarded by the Board under condition that the citizens in Arkansas would complete the levee above Arkansas City to the hills on the south side of Cypress Creek, and to close all small gaps and repair the levees as far as to Matthews Bend. By so doing it was ex- pected to cover sixty miles of river front, and concentrate the water over the bad reaches at Choctaw Bend and Leland and Vancluse crossing, instead of simply closing the four miles at Ashton, an old, thickly undergrown, and deteriorated outlet.

List of levees, third district.

LOUISIANA—TENSAS FRONT.

Contractors.	Name of levee.	Cubic yards.	Price per cubic yard.	Total cost of earthworks.
Hugh Carlisle	Upper Delta to Bedford	248,000	$0 23	$57,040
Luke Madden	Sparta, above Duckport	42,000	18½	7,770
J. B. Reid	Milliken's Bend to Cabin Teel	96,000	19	18,240
Hugh Carlisle	Omega to Milliken's Bend	190,000	21	39,900
Mayer & Co	Raleigh to Willow Point	50,000	22	11,000
Houston & Co	Willow to Raleigh	390,000	24	93,600
J. B. Reid	Lake Providence Reach	60,000	22	13,200
		1,076,000	22.46	240,750

ARKANSAS—TENSAS FRONT.

Winters & Walsh	Duffin Break	87,000	$0 24¾	$21,533
Street & Craig	Panther Forest	175,000	25	43,750
		262,000	24.91	65,283

MISSISSIPPI—YAZOO FRONT.

Mayer & Co	Magna Vista to Chotards	50,000	$0 22	$11,000
Arnold & Co	Shiloh to Tennessee	40,000	24¾	9,900
Hugh Carlisle	Ellerlie	111,000	20	22,200
Strang & Co	Skipwiths	91,000	18	16,380
Strang & Co	Longwood	70,000	18	12,600
James Madden	Jenkins to Easton	84,000	24¾	20,790
Clay & Miller	Roland to Jenkins	175,000	28½	49,875
Fruin & Co	Clay and Bayetts to Roland	177,000	29	51,330
Fruin & Co	Wade Breaks	97,000	24	23,280
Fruin & Co	Hughes Breaks	22,000	24	5,280
Fruin & Co	Beulah to Hughes	152,000	28	42,560
Fruin & Co	Beulah Enlargement	107,000	29	31,030
Scott & Lamb	Beulah 1 to 9	32,000	28	8,960
J. F. Stokes	Riverton Breaks	172,000	27	46,440
		1,380,000	25.55	351,625

RECAPITULATION.

Division.	Cubic yards.	Average.	Total cost.
1. Tensas Front, Louisiana	1,076,000	$0 22.46	$240,750
2. Tensas Front, Arkansas	262,000	24.91	65,283
3. Yazoo Front, Mississippi	1,380,000	25.55	351,625
	2,718,000	24.20	657,658

Statement of work done.

LEVEES—TENSAS AND YAZOO FRONTS.

YAZOO FRONT.

Riverton levee:

	Cubic yards.
Embankment	56,714
Muck ditch	4,496
Heavy clearing, 80 per cent.	
Shiloh to Tennessee, embankment	7,235
Roland to Jenkins, embankment	24,132
Beulah Breaks, embankment	20,000
Total work done on Yazoo Front	112,577

TENSAS FRONT.

Duffin Break, Arkansas:	
Embankment	21,500
Heavy clearing, 20 acres.	
Panther Forest, Arkansas:	
Embankment	20.800
Heavy clearing, 66 acres.	
Sparta, Louisiana:	
Embankment	1,808.9
Muck ditch	2,251
Wilton to Raleigh, Louisiana:	
Embankment	9,596
Excavation	845
Clearing, 20 acres.	
Omega, Louisiana:	
Embankment	37,296
Muck ditch	5,322
Cabin Teel, Louisiana:	
Embankment	17,133
Muck ditch	3,655.8
Total work on Tensas Front	110,207.7

Total November estimates not received.

The contractors are all engaged at their work, and there is every reason to believe that with good weather the work will be completed by March 1, 1883.

A survey party is now engaged running continuous levels over the Mississippi levees, and under the instructions of the Commission a party will be organized as soon as practicable to locate levees and estimate quantities required to fill the existing gaps on the Tensas front.

FINANCIAL STATEMENT.

YAZOO FRONT.

Expended, as follows:	
Contractor's estimates	$28,435 49
Services	1,511 00
Miscellaneous	112 61
Total	30,059 10

TENSAS FRONT.

Expended, as follows:		
Contractor's estimates		28,888 06
Services		2,616 05
Instruments		1,319 35
Subsistence		177 93
Miscellaneous		637 20
Total		33,638 59
Expended:		
Yazoo front		30,059 10
Tensas front		33,638 59
Total		63,697 69
Allotment for "Yazoo front"	$359,050 00	
Expended for "Yazoo front"	30,059 10	
		328,990 90
Allotment for "Tensas front"	323,840 00	
Expended for "Tensas front"	33,638 59	
		290,201 41
Balance available		619,192 31

L 1.

REPORT OF ASSISTANT ENGINEER H. ST. L. COPPÉE UPON THE WORK AT DELTA POINT, VICKSBURG HARBOR.

UNITED STATES GOVERNMENT WORKS, DELTA, LA.,
November 30, 1882.

CAPTAIN: In accordance with verbal instructions received from you November 24, I have the honor to submit a map of Vicksburg harbor, showing position and extent of work up to date; also a description of methods adopted and under way for preserving the bank here against the erosive action of the water.

Heretofore, or since the work of holding Delta Point was begun, the lower bank, or that portion below, say, eleven feet on the gauge, only was protected, with some few exceptions, where mattresses were sunk in high water, no attention being paid to the upper bank. This work was carried on by sinking mattresses about 150 by 50 feet, the mattresses constructed on a wire netting of No. 8 wire with 2-foot meshes, three layers of brush being sewed to the netting with No. 12 wire. This was found to be expensive, but a strong and reliable mattress.

Also permeable screen dikes were sunk in panels 20 by 40 feet, joined together with shackles, the number of panels depending on the depth of water, and extending well above low-water level. The screens were held in place in the stream by means of cribs filled with stone and sunk for that purpose. These screens I found, when the water became low enough to observe them, badly broken up (September, 1882); they had accomplished during the season of high water nothing appreciable but the pocketing of the bank immediately below them.

A hard buckshot ridge (shown on map) was also in previous years taken as a base for a mattress dike, thick mattresses being constructed and placed upon it in layers with intervening layers of stone to hold them in place.

This dike stands between 35 and 40 feet above low water, and has successfully withstood the action of the water for over two years; during the last high water it influenced and increased the caving just below it considerably. The general plan of operations this year, *i. e.*, since the work has come under your direction, has been not only the revetting of the bank with mattresses below the low-water line from where last year's work stopped, but also the grading of the upper bank to a slope of about 2¼ to 1 and its revetment, to enable it to withstand the action of the current, waves, &c. The mattresses are constructed after the plan adopted by Major Ernst at his works near Saint Louis.

They are built on ways which were originally erected for continuous wire-mattress construction. These ways are composed of two barges each 150 by 20 by 3 feet deep; the gunwales of cypress, the bottom ones 8 inches and top ones 6 inches thick; the bottoms of the barges are of yellow pine 2½ inches thick. The barges are placed par-

allel to each other, 9 feet apart, and rigidly connected by a beam 8 by 18 inches by 30 feet long bolted across each end. The space between the barges is spanned at intervals of 5½ feet by 4 by 6 inch sills, which support the posts on which the runs rest. There are also horizontal diagonal braces to give stiffness to the structure. The runs are transverse to the length of the barges, and 5 feet 6 inches between centers. They are of 4 by 9 inch cypress, supported by 4 by 6 inch posts, 6½ feet apart, which rest on 4 by 6 inch sills laid across the bottoms of the barges. The runs at the upper end are 13 feet 3 inches above the bottoms of the barges, and at the lower end (8 feet outside of outer barge), within a few inches of the water surface. A floor is placed 4 feet below top of runs and parallel thereto. A platform 8 feet wide projects from the upper side of the ways on a level with the upper edge of the floor, and extends the whole length of the structure. The mode of making the mattress on these ways is as follows:

A low gunwale flat-boat, 170 feet long by 26 feet beam, is placed with bow to the shore and stern into the stream, and held in that position by 1½-inch lines leading to deadmen on the bank, and anchors in the stream above. On the lower (down stream) side of this boat and firmly held to it by 1-inch lines are the ways placed with the lower end of the runs up stream, and the bows of the barges against the bank. The position of these two boats is now directly over that portion of the lower slope of the bank which is to be reveted. The construction of the mattress is commenced by laying 30-foot willow poles, 5 inches at large end, across the runs and near their lower ends. These poles are lapped from four to six feet, and fastened together with No. 12 wire and four or more 6-inch boat spikes. The number of these poles depends upon the width of mattress desired. Longitudinally between the runs, about 6 feet apart, are placed willow poles of the same dimensions, or perhaps a little smaller with their large ends resting on the transverse system, and tightly wired and spiked to them. Another set of transverse poles fastened in same manner as the first are then placed on the butts of the last-mentioned poles, and all three sets wired and spiked together with No. 12 wire and 10-inch spikes. Before commencing to weave the mattress this upper end or frame is fastened by 1-inch lines to the low gunwaled flat to which ways are held. Brush is then woven over and under the longitudinal poles, the brush being about 30 feet long by 3 inches at the but. The weaving is accomplished by placing the brush over the outside pole under the next, over the next, and so until its end is reached, when it is forced down the runs and poles until the transverse poles are reached, to which, by means of mauls, it is caused to fit tightly; this operation is carried on all along the ways by different gangs of men and repeated until the 30 feet of poles is nearly filled with woven brush, only space enough being left to spike and wire on new poles on which to continue the weaving. In conjunction with this work thirty and forty penny nails are driven through the butts of the brush on the inside and outside edge of the mattress, fastening them to the inside and outside longitudinal poles respectively. At every hundred feet in length of the mattress tranverse poles similar to those at the upper end are used in order to give it more strength, also longitudinal poles are placed and bound on it twelve feet apart for the purpose of forming a crib to keep the rock from rolling off when sunk in deep water; the number and size of these depend entirely on the slope of the bank. When a mattress is constructed to the upper end of the runs and therefore covers the entire ways, it becomes necessary to take it off in order to continue the operation and make it the desired length. (We are making them about 300 feet long.) To do this the lines holding the ways to the flat-boat are slackened and the ways caused to drift down by the impact of the current, and in so doing slide from under the mattress. Should the current not have sufficient force, they are pulled down by means of capstans (fastened below the working platform) holding lines to anchors and the shore below. The ways are only moved the length of a pole for each shift until the end of the mattress is reached, when they are taken away and the mattress allowed to float, held at the end by the flat-boat, and at its shore side by one-inch lines leading to deadmen thirty feet apart. In order to sink the mattress, boats containing rock are brought to its outer edge and fastened there with lines at intervals of ten feet; it is then loaded uniformly with the rock until there is a heavy strain on these lines. At a word the lines are cut, and as it sinks the barges are pulled over the surface it occupied, and rock thrown out in quantities sufficient to insure its remaining on the bottom. The number, size, and position of the lines depend on the force and direction of the current or currents and the depth of the water. After the mattress is sunk, sharpened piles are driven through its shore side to guard against its sliding should the slope be steep. The mattresses now being constructed are 150 by 280 feet.

We make from 60 to 70 feet per day with 52 men; 30 men to do the weaving, 6 at the mauls, 6 handing the willows from barge to ways, 6 binding poles, and 4 linesmen.

The mats are always made to lap, the upper edge of the lower mat lapping over the lower edge of the upper one at least 15 feet.

The piles are willow, 35 to 45 feet long, and from 14 to 18 inches at the butt. They are driven, 25 feet apart, 15 to 20 feet into the ground, and stand, on an average, 15 feet above the present water level, which is 12 feet on the gauge.

Last year it was proposed by the engineer in charge to grade the upper bank, and for that purpose a Dayton cam pump (with steam cylinder 16½ by 18 inches, and water plungers 9 inches diameter, two 4-inch discharge pipes, also a boiler 42 inches in diameter and 20 feet long, with two 14-inch flues) was purchased and fitted up on a barge 16 feet beam, 98 feet long, and 3½ feet hold. It was supposed this pump would excavate the bank at 2 cents per cubic yard, but on attempting it this season I found it to be a failure in the tenacious earth of which the Delta Point is composed.

I was grading the bank at heavy expense by hand (shovels, picks, &c.) when you suggested bringing down from Wilson's Point one of the large graders idle at the time. November 7 hydraulic grader No. 1 reached here, and has been constantly at work up to date. As the pumps, other machinery, and barge were built under your direction, and is in great part of your own designing, a detaild description here will be unnecessary. The mode of working them for grading the bank to a p roper slope to receive the brush and stone revetment is as follows:

The bow of the grader being placed against the bank, and the boom pipe and stages lowered, the hose is laid, leading from the openings in the pipe to within about 8 feet of a face which has been cut in the bank, as a slope guide, and also as the only practicable way of undercutting the steep bank and carrying forward the grade. The nozzles, which are attached to the end of the hose, rest and are turned on a swivel turning in an oak frame or trestle built for that purpose and spiked well to the ground. Each nozzle is worked by three men. Three nozzles are used. The slope is carried a little ahead at the upper end; the reason for this is that by so doing the water, after spending its force on the bank, on seeking a lower level, is caused to run close to the lower end of the face, helping to undercut it, whereas were the bottom of the face in advance it would run in numerous small streams, destroying rather than helping the condition of the slope. The direction of each stream is always at a greater or less angle than 90° to the face, as otherwise they would form pockets in the bank, with cushions of water in them, which resist the pressure. It is sometimes also advantageous to cut the face in planes at right angles to the slope, but no general rule can be adopted where the position and composition of the strata vary as they do here. We find the best results to be obtained from 4-inch hose and 1¾-inch nozzles, but if we had 1¼-inch nozzles in connection with our 4-inch hose, we would do still better work. Two-and-a-half-inch hose gives comparatively poor results, the friction decreasing appreciably the force of the discharge. We have used also 4-inch hose to within a few feet of the nozzle rest, and there, by means of a Y, connected two 25-foot sections of 2½-inch hose, and at their ends 1¼-inch nozzles. This method, in my opinion, is also inferior to the large hose, the only advantage gained by it being the greater facility with which the nozzles are manipulated.

The bank graded here has been nearly perpendicular. We endeavor to slope it 2¼ to 1, the guide slope at the face being flatter. The sand and soft deposit is carried off with great rapidity by the force of the water, but the tougher and more tenacious material, such as clay and buckshot, of which this bank is in great part composed, resists formidably its cutting. To this resistance and the necessarily greater quantity of water discharged at such points is due the caving away of the bottom of the slope; this, though, is unavoidable. This work is greatly simplified and cheapened as the hands employed become trained. We have to pay them better wages than the ordinary laborer and furnish them with water-proof clothing.

Mr. Steubing reports on an average, with three nozzles, during the last week, 1,300 cubic yards of earth moved per day, at less than 4 cents per cubic yard. After grading as nearly as possible to the stakes with the grader, the inequalities left are removed by shovels, the earth being thrown into a trough (2 feet by 1 foot in sections, and leading from the top to the bottom of the slope), through which a continuous stream of water runs, supplied by the Dayton cam pump (which was found to be unfit for the heavier work), and carries off the earth, in this manner saving eight times the labor which would be necessary in order to move it dry. After the bank is thus dressed, continuous lines of poles 30 feet long by 5 inches, well wired and spiked together, are laid on it parallel with the top, and 10 to 12 feet apart; on these, spiked and wired to them in the same manner, are transverse lines reaching from the top to the bottom of the slope (also 10 to 12 feet apart). These two sets of poles form a frame, upon which willows are laid (20 to 30 feet long and 2 inches at butt), with the butts up the hill, the brushy or leafy part of the top row being covered by the butts of those below, and so on until the water's edge is reached. On the brush are placed longitudinal poles, directly over those in the bottom frame and fastened to them by No. 8 wire. This revetment is fastened to or overlaps that on the lower slope. Should a space intervene between the piles and the upper revetment, foot-mats similar to the latter are built and sunk, with the piles as a guide. As the water rises stone is placed on the upper revetment, just enough to hide the willows.

I inclose sketches of revetment and strata of earth through which we are now grading.

During the season, *i. e.*, from about the 1st of October to date, we have revetted approximately 1,100 feet of the lower and 1,100 feet of the upper bank; the latter with the exception of the stone, which is put on cheaper as the water rises. The exact amount and position of the work will be sent you in sketch accompanying the monthly report.

I am having all the material used on the above construction measured and weighed, and hope soon to submit a very near estimate of its cost per linear foot.

The willow brush used in the above work is cut on Delta Point Bar, three-fourths of a mile back from the river, and hauled thereto on a tramway by cars made for that purpose; the motive power is a mule.

I made no contract for piles, but have my own men cut them and send them down the river in rafts of sufficient numbers to keep the driver at work. I forwarded to you last week a list of all the floating property, barges, &c., used on the work.

Yours, very respectfully,

H. ST. L. COPPÉE,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

APPENDIX M.

REPORT OF MAJOR AMOS STICKNEY, CORPS OF ENGINEERS, UPON OPERATIONS CONDUCTED IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
NO. 3 S. RAMPART STREET,
New Orleans, La., December 1, 1882.

SIR: In compliance with the request of the president *pro tempore* of the Mississippi River Commission, dated on board of steamer Mississippi, Memphis, Tenn., November 19, 1882, I have the honor to report as follows on the several works of improvement in my charge, under the supervision of the Commission, from August 2, 1882, the date of the passage of the act making appropriations therefor, to December 1, 1882.

IMPROVING MOUTH OF RED AND ATCHAFALAYA RIVERS.

In the river and harbor act passed August 2, 1882, an appropriation was made for continuing the work of improvement, Capt. A. M. Miller, Corps of Engineers, U. S. A., being then in charge. Under authority from the Chief of Engineers, U. S. A., dated August 28, 1882, a stern-wheel steamboat and two tug-boats were hired, at a rate of $65 per day each. Some necessary repairs were made to the dredge-boat engaged on the work last season, and work was commenced with this plant on the old river between the Atchafalaya and Mississippi September 12, 1882, and continued without interruption. The work was transferred to my charge September 30, 1882, under authority from the Chief of Engineers, dated Washington, D. C., September 9, 1882. No change was made in the manner of conducting operations. The dredge-boat has excavated 25,200 cubic yards of material from the mouth of Red River, and made two cuts, giving a channel depth at last accounts of 16 feet, and width of 250 feet over the outer bar.

The plant, consisting of the two tugs and one steamboat, have been engaged from the 18th of August to December 1, 1882, in working between the mouths of Red and the Atchafalaya Rivers, and on the bar at the mouth of the Atchafalaya River. Navigation has been kept uninterrupted during that time. At date of last report a channel depth existed of from $5\frac{1}{2}$ to 6 feet, this being sufficient for the boats navigating these rivers. Work was suspended at the end of November, 1882, in consequence of high water making it no longer necessary, and the plant was returned to New Orleans to the owners.

IMPROVING HARBOR AT NEW ORLEANS, LA.

A project, with estimates based on the recommendation of the Board of Engineer Officers convened by Special Orders No. 97, dated Headquarters Corps of Engineers, U. S. A., September 12, 1881, was presented to the Commission on September 16, 1882, and was approved by the Commission September 18, 1882. No work has been done under this project, as the time required for preparation of plant will make it nec-

essary to wait until next low-water season. Soundings have been made each month, with one or two exceptions, in the third district harbor front, to ascertain what changes, if any, have taken place in the banks and bed of the river. These soundings will be continued.

IMPROVING HARBOR AT NATCHEZ AND VIDALIA.

No work has been done since the month of March, 1882, high water causing a total suspension of operations. A force of watchmen have been employed to take care of engineer property.

The transfer of this work was made to me by Capt. A. M. Miller, Corps of Engineers, U. S. A., September 8, 1882, in obedience to Special Orders No. 89, Paragraph 1, Headquarters Corps of Engineers, U. S. A., Washington, D. C., August 30, 1882. A project for carrying on the work will be submitted as soon as practicable.

LEVEES.

The construction and repair of levees in the fourth district having been assigned to me in Engineer Department letter of August 29, 1882, preparations were immediately made for fitting out and dispatching survey parties for the purpose of surveying and locating the lines for the levees in the district. Three parties were sent into the field, each under the charge of an assistant engineer, early in September, with full written instructions embodying the experience of State engineers. After some delays, caused principally by sickness and the obstructed condition of some lands through which the levee lines were located, the different parties completed the work assigned to them during October, 1882. The Board of Engineers constituted by Special Orders No. 88, Headquarters Corps of Engineers, U. S. A., Washington, D. C., August 29, 1882, assembled at Memphis, September 4, 1882. Bids were invited by publication in the principal newspapers for building levees, and printed specifications were issued to parties applying. The bids received were opened at Memphis September 25, 1882. Some of these being considered too high, and others being made conditionally, the Secretary of War authorized the rejection of objectionable ones and the readvertisement of these, by circular letter. Contracts were made with the several parties to whom awards had been made, and were duly approved by the Chief of Engineers.

The contractors commenced work on their respective levees almost immediately, except on the Hardscrabble and Bondurant levees and Atchafalaya to Red River Landing levees, both of which were under contract with the same person, G. A. Meyer. After waiting some time for this contractor to commence work on these levees, and considerable complaint from interested planters having been received, no proper effort was made by him to push these levees, and on November 28 and 29 I recommended to the Chief of Engineers the annulment of both of his contracts for the reason that he had failed to exercise that "due diligence" required in his contract. No reply to my recommendations has been received at date of this report.

The following is a detailed statement of work at the different localities:

POINT COUPÉE CREVASSE.—G. A. MEYER, *contractor*.

This work was commenced about the middle of October with a small force of laborers, &c., but the number of laborers has been increased of late by the contractor withdrawing his forces from another levee. At latest report from the inspector, fair progress had been made, an estimate of 450 yards of levee being put up daily, with promise of more rapid work.

STEWART CREVASSE.—G. A. MEYER, *contractor*.

No work of consequence has been done. The contractor completed 500 feet of muck ditch, and withdrew his forces to place them on the Point Coupée levee. This levee is small and does not need as energetic pushing as the others.

RACCOURCI CREVASSES.—C. L. HARDEMAN, *contractor*.

Work was commenced early in October, and rapid progress has been made. The force daily employed consists of 100 men, with scrapers and barrows, and a good number of animals, horses, and oxen being used as needed. The contractor has four thousand feet of levee under construction, and it is estimated that about twelve hundred cubic yards of embankment are fielded in daily. It is probable that the contractor will complete his contract by January 15, 1883.

HOG POINT TO RACCOURCI.—N. W. IRISH, *contractor.*

Work commenced with a small force. There are now fifty men and twenty-five teams at work daily, and present progress is good. No details of work are given, as none have so far been received from inspector.

ATCHAFALAYA TO RED RIVER LANDING.—G. A. MEYER, *contractor.*

This contract was recommended by me to be annulled in consequence of lack of "due diligence" on the part of contractor, no work having been commenced.

GREEN'S TO FAIRVIEW.—R. G. HUSTON & CO., *contractors.*

The work has been slow here, scarcity of labor being assigned by the contractor as the cause. At date of last report about 400 feet of timber had been cleared along base of levee and 600 feet of light brush.

A muck ditch has been completed for 1,400 feet, 1,000 feet of which has been refilled and tamped. Embankment is being constructed on eleven stations with scrapers and barrows.

LAKE CONCORDIA BREAKS.—KIERNAN & PHELAN, *contractors.*

Some delay occurred in the commencement of work on this levee, on account of much sickness in the survey party engaged in locating lines of work. Fair progress is being made, and the contractors have a good force on hand.

KEMPE EXTENSION.—P. J. KENNEDY, *contractor.*

Operations have been conducted with vigor, and the progress made shows satisfactory results. A large force is engaged and all the timber is cleared. Levee construction is advancing very fast. An inspector is just now making up estimates of work done.

HARDSCRABBLE AND BONDURANT.—G. A. MEYER, *contractor.*

This contract was recommended to the Chief of Engineers by me November 28, 1882, for annulment, in consequence of a lack of due diligence on the part of contractor in commencing work. Nothing has been done by him on the work. No reply has yet been received from the Chief of Engineers to my recommendation for annulment.

SHIPP'S BAYOU TO HARD TIMES.—P. G. MEATH, *contractor.*

This contractor is reported as being very able and energetic, and his work has been carried on satisfactorily. He commenced operations with 132 men and 52 wheelbarrows, and has since increased the number of men to 160. Estimates of amount of work completed are now being made up by the inspector.

CASTLEMAN'S TO BUCK RIDGE.—JAMES MADDEN, *contractor.*

Work was commenced November 2, and although there are but thirty men, seven scrapers, and sixteen wheelbarrows working, good progress is being made. The contractor is reported as being both able and willing to complete his work as soon as possible.

Estimates are now being prepared of amount of work done.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers, U. S. A.

To the EXECUTIVE OFFICER,
Con. Dept. Miss. River Commission, Saint Louis, Mo.

APPENDIX N.

A PAPER BY HENRY MITCHELL, MEMBER OF THE COMMISSION, SUBMITTED BY THE COMMITTEE ON LEVEES AND OUTLETS, UPON BENDS; THEIR RELATIONS TO DEPTH AND SECTION IN THE LOWER MISSISSIPPI RIVER.

The portion of the river examined lies between a point 4½ miles below Fort Saint Philip and another point near Point Houmas, distant 150¾ miles. We have used the original hydrographic sheets of the Coast and Geodetic Survey, on each of which the soundings are reduced to the lowest stage during the season. This portion of the river receives no considerable tributary and has no important outlet—unless Bonnet Carré Crevasse be so regarded, which certainly does not influence the form of the river-bed to any great distance.

The elements of the river from the general means, for the entire distance, 150¾ miles, corresponding to an air-line distance of 105 miles, are:

Mean width, 2,337 feet.

Mean depth, 60 feet.

Mean channel depth, 98 1/10 feet.

Mean area of section, 140,000 square feet.

The study has led to several conclusions, some of which are rigidly inductive, while others are inferential and will be so distinguished.

Inductions.—1. Bends, as increasing the depth of the river, offer, on the whole, no advantage. (See Table No. 1.) They cause a depression of the bed at the turns and a corresponding elevation at the reversions.

2. The mean depth of cross-section, and the channel depth, vary with inverse radius of curvature, or, practically, with angles of deflection. (See Table No. 2.)

3. The variation of channel depth with curvature is limited; the gain of depth with deflection ultimates essentially at 23° to 25° for half-mile chords, and within this limit is nearly proportional. The mean depth increases with curvature at about half the rate found for the channel depth, and within the scope of our observations exhibits no limit.*

Inferences.—There appears to be a decrease (comparatively small) of river widths with distance going up river, and also a decrease with curvature—both irregular, and regarded as inconsiderable as affecting the relations of other variables mentioned under the head of *Inductions.*

There is a tendency, at reversions, where one centrifugal force overlaps the other, to divide the stream and induce scour near both banks, with central shoaling.

Since the shallow water at the reversion seems to be the result of loss of energy by the stream, due to its scour in the bend above, it may be inferred that *equality of depth is incompatible with uniformity of width, and that a forced contraction at reversions becomes necessary to remove the bars.*

Details.—Accompanying this report, but not designed for printing, are the earlier tables, from which those referred to above are reduced. These data have all been again and again reviewed; and Messrs. Sullivan and Granger, of the Coast and Geodetic Survey, upon whom the labor has fallen, having had the training of many years both as surveyors and computers, we may feel confident that the best and truest use has been made of the observations.

A note appended to the detailed tables explains the rejection of four sections out of three hundred and two, and some other less important incidents in the computations. It also furnishes the names of the chiefs under whom the surveys were made, with dates, &c.

B. M. HARROD,
CHAS. R. SUTER,
HENRY MITCHELL,
Coast and Geodetic Survey.

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*For the sharpest turns—those falling between 53° and 60° of deflection with half-mile chords—the instances are so few that the apparent increase at higher rate which they indicate must be regarded as doubtful. It was designed to group the data for every 10° of deflection, but we had not enough to warrant this always.

Where there are few data, as between 53° and 60°, discrepancies in the planes of references may disturb the final result, which could not happen in larger groups.

TABLE 1.—*A comparison of air-line and river distances with mean depths, mean widths, and mean areas in Mississippi River, beginning in latitude* 29° 20′ 46″, *longitude* 89° 24′ 16″, *and ending in latitude* 30° 06′ 36″, *longitude* 90° 54′ 47″.

[The air-lines follow the course of the river by a polygon of 6.345 miles to the side.]

Sections.	Polygon sides.	River distance.	Mean channel depth.	Mean width.	Mean depth.	Mean area.	Remarks.	River distance.	Mean channel depth.	River distance.	Mean channel depth.	Remarks.
		Stat. m.	*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Miles.*	*Feet.*	*Miles.*	*Feet.*	
	0	0					4½ miles below Fort Saint Philip.					The data given under the head of "mean channel depth" correspond to the half-mile chord below the angle of deflection. These depths are the means of all the soundings for each half-mile following the line of greatest depression. The design of this table is to illustrate the obliteration of bend effect in groups taken in geographical order, which include both bends and reversions.
1 to 17	1	8.00	121.1	2,406	74.0	174,865						
18 to 30	2	6.75	101.1	2,515	58.7	147,439						
31 to 45	3	7.25	110.0	2,220	66.9	145,267		3 to 6	98.1	2 to 8	97.8	
46 to 58	4	6.50	94.0	2,454	57.6	140,812						
59 to 71	5	6.50	96.4	2,508	57.3	140,208						
72 to 83	6	6.25	92.0	2,408	54.3	130,392						
84 to 97	7	6.75	100.5	2,279	63.0	142,161						
98 to 111	8	7.00	89.8	2,343	55.2	128,418						
112 to 123	9	6.25	90.9	2,183	58.7	127,517		9 to 13	96.1			
124 to 161	10	18.75	97.0	2,250	64.8	143,305						
162 to 179	11	9.00	102.1	2,433	63.4	151,103						
180 to 195	12	8.00	98.6	2,350	59.3	136,128						
196 to 209	13	7.00	91.8	2,357	56.1	130,200						
210 to 223	14	7.25	84.5	2,309	50.8	115,350	3 sections rejected.	14 to 17	91.6	14 to 19	95.3	
224 to 241	15	8.75	92.9	2,371	56.3	131,991	1 section rejected.					
242 to 255	16	7.00	98.1	2,229	62.4	138,111						
256 to 269	17	7.00	90.7	2,243	62.4	139,204						
270 to 288	18	9.50	90.3	2,442	55.2	133,693						
289 to 302	19	7.25	115.1	2,107	63.4	133,829	Near Point Houmas.					
Mean			97.8	2,337	60.0	138,421						

The length of river covered by the above table is 120½ miles by "polygon sides," 150¾ by "river distance," or 105 miles by "air-line."

TABLE 2.—*Bend effects, Mississippi River.*

[From 4½ miles below Fort Saint Philip to near Point Houmas, 150¾ miles.]

Number of data.	Limits of included angles, ½-m. chords.	Mean deflection.	Radius of curvature, ½-m chord.	$\frac{31522}{\text{Radius of curvature.}}$	Mean width.	Mean depth.	Mean area of section.	Number of data.	Mean channel depth.
	°	° ′	*Feet.*		*Feet.*	*Feet.*	*Feet.*		*Feet.*
4	120 127	54 23	2,889	10.91	2,175	90.9	196,762	4	129.3
11	134 147	40 16	3,833	8.22	2,273	73.0	162,827	10	119.4
29	151½ 160½	23 33	6,468	4.87	2,290	67.6	152,509	29	116.4
71	161 170	13 27	11,272	2.80	2,262	62.2	38,504	70	102.5
175	170½ 179½	4 48	31,522	1.	2,375	57.6	135,493	173	92.0
8	0	0	.....	....	2,362	54.8	129,237	8	82.3

APPENDIX O.

REVIEW OF SURVEYS AND GAUGINGS OF CUBITT'S GAP, MADE IN 1868, 1875, AND 1876, BY HENRY MITCHELL, COAST AND GEODETIC SURVEY.

NOVEMBER 16, 1876.

DEAR SIR: In response to your instructions, I offer the following review of the results obtained by the Coast Survey in its examinations of the new outlet of the Mississippi River known as Cubitt's Gap.

Cubitt's Gap, so named from the owner of an adjacent portion of the river bank, originated "during the late war from a cut made by the Navy through the bulkhead of a fisherman's canal to provide a boat passage to the oyster beds."*

The topographical survey of Mr. C. H. Boyd, assistant, Coast Survey, in 1868, showed the extreme limits of the opening through the river bank to be 2,427 feet; but three islands, then remaining, reduced the clear water-way to 2,087 feet. At the date of the first survey of Mr. H. L. Marindin, assistant, Coast Survey, June, 1875, the extreme width of the opening was found to be 2,746, and the clear water-way 2,617 feet; and at the date of the second survey by the same officer, made in February, 1876, the linear measure was so nearly the same that we concluded that no superficial change had occurred in the eight months that had elapsed except a slight washing away of the islands.

The area of the section at the gap according to the survey of 1875 was 129,000 square feet, and according to the survey of 1876, 119,000 square feet, an apparent loss of nearly eight per cent. The great depth in the opening and the whirling outflow made close measurements impracticable, so that, with a decided preference for the measure obtained in 1876, which is the most careful, we conclude that if any change did occur in the interval between the two surveys, it was *reduction*.

The stage of the river to which these figures correspond was *flood*, the surface elevation at the Head of the Passes being about one-tenth of a foot below the bench at the center of the flat circular foundation of the old light-house (the astronomical station occupied by the Coast Survey in 1857).

The section found for Cubitt's Gap, 119,000 square feet, is 70 per cent. of that of the main river, a short distance above this crevasse. This, however, by no means represents its true capacity as an outlet, for within one hundred and fifty feet as we go seaward, the loss of area amounts to 30 per cent., and within a mile from the center of the gap the sum of the sectional areas of all the passes amounts to but 58,748 square feet, or only 34 per cent. of the main river section. Our conclusion from these results is that the gap has been created mainly by the impact of the main river current upon the slender bank, causing this bank to give way as it became undermined. In other words, it is not a case of frictional scour, since no such section could have

* Report of commission appointed to investigate and report a permanent plan for the reclamation of the alluvial basin of the Mississippi River subject to inundation.

been, or was, subsequently maintained. The section of the gap, if it had been due to the scour of the outflow, would have had less area than the sum of the sections of the passes beyond instead of *three times as much*. One may easily conceive that a cut having been made through the natural bank it rapidly enlarged, because the river, expanding into the opening, impinged upon the lower side of the cut which presented *abrupt obstruction* (technically speaking).

Thus in Cubitt's Gap it was the *lower side* (down river) that gave way so as to enlarge the extreme opening between 1868 and 1876. The islands, under similar influence of *impact*, also crumbled away and increased the clear water-way in still greater proportion.

If this view of the case is correct we might expect older (up river) portions of the crevasse to grow shallower, whether the width of the opening increased or not, the section having become greater than the outflow requires. We, however, do not find in the eight months' interval between Mr. Marindin's surveys that shoaling in this order has taken place. The shoaling observed, which is doubtful, appears in the great depths.

The result for discharge, furnished by Mr. Marindin at the close of his work in 1875, appeared to us so large that you instructed a repetition of the work with another location. Accordingly he was advised to make his observations in the passes seaward of the gap, where the depths were presumed to be more uniform.

Beyond the gap the outflow expands and constructs for itself four regular *passes* and a *bayou* through which it seeks the sea. It was in these five avenues that the gaugings of 1876 were made at the flood stage mentioned above. The gross discharge obtained was 124,666 cubic feet per second. With this new result before us it is easy to discover the principal source of error in the previous work, which lay not in careless field work, but in the improper compilation of the observations. The velocities obtained in the first trial were multiplied into the depths at the stations along the line of greatest depression without taking into account the distance from the boat (or anchor) to the instruments.

Going back to the original field-notes and introducing these distances at the ordinary scale, we reduce the section so materially that the discharge proves to have been not more than nine per cent. greater in 1875 than it was in 1876.

The observations of 1876 in the passes and the bayou beyond Cubitt's Gap were made on the same day, and all within a period of two hours, so that the change in the diurnal tide of the Gulf may be neglected and the results assumed to be simultaneous. We give below a table showing the *width*, *mean depth*, *mean velocity*, and *direction* of the stream at the gauging place in each of the five avenues.

Number of pass and section.	Width of section.	Mean depth of section.	Mean velocity of section.	Direction of flow.	
	Feet.	*Feet.*	*Feet per second*		
1	972	5.78	1.81	N. 29° W.	
2	2,943	7.33	1.91	N. 18° E.	Main pass.
3	1,234	7.35	2.02	N. 59° E.	
4	3,600	5.45	1.60	S. 69° E.	Exclusive of flat.
5	258	5.98	1.96	N. 58° E.	Bayou.
Means	.....	6.38	1.86	.....	

NOTE.—Section 4 crosses a pass which has a double channel, giving the section an uncertain character. Mr. Marindin has suggested that the flat lying between the two channels, over which he could discover no flow, should be excluded, and it has been in the foregoing table.

We were much surprised on first discovering the general agreement among the results for mean depths and mean velocities, the widths and directions being so very unlike; but Professor Pierce, whom we consulted, gave us the key to the mystery in suggesting that the outflow must have reached a resisting stratum limiting the depth, and limiting therefore the velocity (the square of the velocity being variable with the hydraulic mean depth).

On going back to the hydrography executed before these passes were constructed, we find that the present depths are not much greater than they were before; so we conclude that Cubitt's Gap opened upon flats which long exposure to the dash of the sea had reduced to hard sand, like that forming other exposed flats in this neighbor-

hood, and that this packed sand resists the scouring action of the water somewhat as the hard sand of the South Pass Bar resisted, for a while, the stronger current induced by Mr. Eads's jetties.

The above explanation, while exceedingly complete and satisfactory as such, takes away somewhat the interest of the appended tables which we had prepared to show the *coefficient* of scour (column "*g*"); because the *beds* of these passes differing from their *banks*, more widely perhaps than in any of the old passes of the main river, our study brings us to no safe generalization of phenomena.

Appended to this report are six tables and an illustrative diagram. These require no explanation, except as regards the relation of velocity with depth.

The coefficient used in column "*d*" is simply one of *scale* in order to compare the observed transverse curve of velocities with the observed depth in our diagram.

The coefficient in the column "*g*" is supposed to have a real significance, connecting cause and effect. Its mean value is 1.56; or, if we exclude the *bayou* (section 5), 1.68, from which the largest deviation is 0.18 for section No. 2.

For the main river, at a section just above Cubitt's Gap (see No. 6), the coefficient for V^2 is 2.22, *i. e.*, one-third larger than in the shallow passes beyond Cubitt's Gap.

In the diagram the results plotted are those from column *l* and *d*—the latter involving *coefficient of scale*, as above stated.

Very respectfully, yours,

HENRY MITCHELL,
United States Coast Survey.

CARLISLE P. PATTERSON, Esq.,
Superintendent United States Coast Survey.

No. 1—*Section on C. D. beyond Cubitt's Gap.*

a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	
Distance from left bank.	Depth.	V in feet per second.	V × coëf. 3.193.	*b*—*d*.	V^2.	V^2 × coëf. 1.553.	*b*—*g*.	Remarks.
Feet.	*Feet.*							
0	0.0	0.0	0.00	+0.0	0.0	0.00	0.0	
100	4.0	1.18	3.77	+0.2	1.39	2.16	+1.8	Mean of *c*=1.810 feet.
200	5.7	1.86	5.94	—0.2	3.46	5.37	+0.3	Mean of *f*=3.720 feet.
300	6.2	2.16	6.90	—0.7	4.66	7.24	—1.0	Mean of depth=5.78 feet.
400	7.0	2.26	7.22	—0.2	5.11	7.93	—0.9	
500	7.2	2.25	7.18	0.0	5.06	7.86	—0.7	Area of section=5,617 square feet.
600	6.8	2.25	7.18	—0.4	5.06	7.86	—1.1	
700	7.2	2.23	7.12	+0.1	4.97	7.72	—0.5	
800	7.6	2.14	6.83	+0.8	4 58	7.11	+0 5	
900	5.2	1.48	4.72	+0.5	2.19	3.40	+1.8	
972	0.0	0.00	0.00	0.0	0.00	0.00	0.0	

No. 2.—*Section on E. F. beyond Cubitt's Gap.*

a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	Remarks.
Distance from left bank.	Depth.	V in feet per second.	V × coëf. 3.837.	$b-d$.	V^2.	V^2 × coëf. 1.856.	$b-g$.	
Feet.	*Feet.*							
0	1.0	0.00	0.00	+1.0	0.00	0.00	+1.0	
100	2.3	0.20	0.76	+1.5	0.04	0.07	+2.2	Mean of $c = 1.91$ feet.
200	4.0	0.74	2.84	+1.2	0.55	1.02	+3.0	Mean of $f = 3.948$ feet.
300	8.0	1.52	5.83	+2.2	2.31	4.29	+3.7	Mean of depth = 7.33 feet.
400	8.4	2.08	7.98	+0.4	4.33	8.04	+0.3	
500	7.7	2.11	8.09	−0.4	4.45	8.26	−0.6	
600	7.7	2.11	8.09	−0.4	4.45	8.26	−0.6	
700	8.0	2.11	8.09	−0.1	4.45	8.26	−0.3	Area of section = 21,573 square feet.
800	7.2	2.11	8.09	−0.9	4.45	8.26	−1.1	
900	5.8	2.11	8.09	−2.3	4.45	8.26	−2.5	
1,000	6.0	2.11	8.09	−2.1	4.45	8.26	−2.3	
1,100	7.2	2.11	8.09	−0.9	4.45	8.26	−1.1	
1,200	8.2	2.11	8.09	+0.1	4.45	8.26	−0.1	
1,300	8.5	2.11	8.09	+0.4	4.45	8.26	+0.2	
1,400	8.3	2.11	8.09	+0.2	4.45	8.26	0.0	
1,500	10.0	2.11	8.09	+1.9	4.45	8.26	+1.7	
1,600	8.2	2.11	8.09	+0.1	4.45	8.26	−0.1	
1,700	7.3	2.11	8.09	−0.8	4.45	8.26	−1.0	
1,800	8.0	2.06	7.90	+0.1	4.24	7.87	+0.1	
1,900	6.8	2.01	7.71	−0.9	4.04	7.50	−0.7	
2,000	5.7	1.99	7.63	−1.9	3.96	7.35	−1.6	
2,100	8.6	2.01	7.71	+0.9	4.04	7.50	+1.1	
2,200	8.5	2.13	8.17	+0.3	4.54	8.43	+0.1	
2,300	8.7	2.20	8.44	+0.3	4.84	8.98	−0.3	
2,400	9.2	2.35	9.02	+0.2	5.52	10.24	−1.0	
2,500	10.8	2.37	9.09	+1.7	5.62	10.43	+0.4	
2,600	10.8	2.31	8.86	+1.9	5.34	9.91	+0.9	
2,700	7.9	2.16	8.29	−0.4	4.66	8.65	−0.7	
2,800	6.0	1.89	7.25	−1.2	3.57	6.62	−0.6	
2,900	2.0	1.01	3.87	−1.9	1.02	1.89	+0.1	
2,943	0.0	0.00	0.00	0.0	0.00	0.00	0.0	

No. 3.—*Section on I. J. beyond Cubitt's Gap.*

a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	Remarks.
Distance from left bank.	Depth.	V in feet per second.	V × coëf. 3.631.	$b-d$.	V^2.	V^2 × coëf. 1.639.	$b-g$	
Feet.	*Feet.*							
0	0.0	0.00	0.00	0.0	0.00	0.00	0.0	
100	3.1	0.90	3.27	−0.2	0.81	1.33	+1.8	Mean of $c = 2.024$ feet.
200	8.0	2.11	7.66	+0.3	4.45	7.29	+0.7	Mean of $f = 4.484$ feet
300	10.8	2.31	8.39	+2.4	5.34	8.75	+2.1	Mean of depth = 7.35 feet.
400	10.3	2.31	8.39	+1.9	5.34	8.75	+1.6	
500	9.5	2.31	8.39	+1.1	5.34	8.75	+0.8	Area of section = 9,081 square feet.
600	8.0	2.31	8.39	−0.4	5.34	8.75	−0.7	
700	8.7	2.31	8.39	+0.3	5.34	8.75	0.0	
800	6.3	2.31	8.39	−2.1	5.34	8.75	−2.4	
900	8.2	2.31	8.39	−0.2	5.34	8.75	−0.5	
1,000	7.7	2.31	8.39	−0.7	5.34	8.75	−1.0	
1,100	7.1	2.23	8.10	−1.0	4.97	8.14	−1.0	
1,200	4.7	1.89	6.88	−2.2	3.57	5.85	−1.1	
1,234	0.0	0.00	0.00	0.0	0.00	0.00	0.0	

No. 4.—*Section on K. L. beyond Cubitt's Gap.*

a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	Remarks.
Distance from left bank.	Depth.	V in feet per second.	V×coëf. 3.406.	$b-d$	V^2.	V^2×coëf. 1.656.	$b-g$.	
Feet.	*Feet.*							
0	4.0	1.43	4.87	—0.9	2.04	3.38	+0.6	
100	5.9	2.25	7.66	—1.8	5.06	3.38	—2.5	First channel.
200	8.6	2.33	7.94	+0.7	5.43	8.99	—0.4	Mean of c=1.435 feet.
300	9.0	2.33	7.94	+1.1	5.43	8.99	—0.0	Mean of f=2.982 feet.
400	9.0	2.33	7.94	+1.1	5.43	8.99	—0.0	Mean of depth=5.17 feet.
500	9.0	2.28	7.77	+1.2	5.20	8.61	+0.4	
600	4.7	1.43	4.87	+0.2	2.04	3.38	+1.3	
700	1.2	0.43	1.46	—0.3	0.18	0.29	+0.9	Area of section = 20,920 square feet.
800	1.0	0.17	0.58	+0.4	0.03	0.05	+0.9	
900	0.9	0.09	0.30	+0.6	0.00	0.00	+0.9	
1,000	0.8	0.00	0.00	+0.8	0.00	0.00	+0.8	
1,100	0.8	0.00	.....	.....	0.00	.....	.....	
1,200	0.8	0.00	.....	.....	0.00	.....	.....	
1,300	0.7	0.00	.....	.....	0.00	.....	.....	
1,400	0.7	0.00	.....	.....	0.00	.....	.....	
1,500	0.6	0.00	.....	.....	0.00	.....	.....	
1,600	0.5	0.00	.....	.....	0.00	.....	.....	
1,700	0.5	0.00	.....	.....	0.00	.....	.....	
1,800	0.5	0.00	.....	.....	0.00	.....	.....	
1,900	0.6	0.00	.....	.....	0.00	.....	.....	
2,000	0.7	0.00	.....	.....	0.00	.....	.....	
2,100	0.8	0.00	.....	.....	0.00	.....	.....	
2,200	0.8	0.00	.....	.....	0.00	.....	.....	
2,300	0.9	0.00	.....	.....	0.00	.....	.....	
2,400	0.8	0.00	.....	.....	0.00	.....	.....	
2,500	0.9	0.00	.....	.....	0.00	.....	.....	
2,600	0.9	0.00	0.00	+0.9	0.00	0.00	+0.9	
2,700	0.9	0.5	0.17	+0.7	0.00	0.00	+0.9	
2,800	1.0	0.9	0.30	+0.7	0.00	0.00	+1.0	
2,900	1.5	0.34	1.16	+0.3	0.11	0.18	+1.3	Second channel.
3,000	4.2	1.18	4.02	+0.2	1.39	2.30	+1.9	Mean of c=1.663 feet.
3,100	8.0	2.37	8.07	—0.1	5.62	9.31	—1.3	Mean of f=3.791 feet.
3,200	9.0	2.57	8.75	+0.3	6.60	10.93	—1.9	Mean of depth=5.55 feet.
3,300	6.7	2.57	8.75	—2.0	6.60	10.93	—4.2	
3,400	9.0	2.55	8.69	+0.3	6.50	10.76	—1.8	
3,500	9.0	2.55	8.69	+0.3	6.50	10.76	—1.8	
3,600	6 2	2.54	8.65	—2.4	6.45	10.68	—4.5	
3,700	7.8	2.54	8.65	—0.8	6.45	10.68	—2.9	For channels combined.
3,800	9.0	2.54	8.65	+0.4	6.45	10.68	—1.7	Mean of c=1.599 feet.
3,900	7.7	2.54	8.65	—0.9	6.45	10.68	—3.0	Mean of f=3.288 feet.
4,000	8.8	2.54	8.65	+0.2	6.45	10.68	—1.9	Mean of depth=5.447 feet.
4,100	8.3	2.45	8.34	0.0	6.00	9.94	—1.6	
4,200	3.0	1.09	3.71	—0.7	1.19	1.97	+1.0	
4,300	2.8	1.12	3.81	—1.0	1.25	2.07	+0.7	
4,400	4.5	1.60	5.45	—0.9	2.56	4.24	+0.3	
4,500	8.1	2.45	8.34	—0.2	6.00	9.94	—1.8	
4,600	8.4	2.45	8.34	+0.1	6.00	9.94	—1.5	
4,700	7.9	2.45	8.34	—0.4	6.00	9.94	—2.0	
4,800	7.4	1.94	6.61	+0.8	3.76	6.23	+1.2	
4,900	2.4	0.47	1.60	+0.8	0.22	0.36	+2.0	
5,000	1.4	0.20	0.68	+0.7	0.04	0.06	+1.3	
5,100	0.7	0.05	0.17	+0.5	0.00	0.00	+0.7	
5,200	0.3	0.00	0.00	+0.3	0.00	0.00	+0.3	
5,300	0.0	0.00	.....	.....	.....	.....	.....	
5,400	0.4	0.00	.....	.....	.....	.....	.....	
5,500	1.2	0.00	.....	.....	.....	.....	.....	
5,600	0.0	0.00	.....	.....	.....	.....	.....	

No. 5.—*Section on C H beyond "Cubitt's Gap."*

a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	
Distance from left bank.	Depth.	V. in feet per second.	V. × coëf. 3.054.	*b*—*d*	V^2.	V^2. × coëf. 1.185.	*b*—*g*	Remarks.
Feet.	*Feet.*							
0	0.0	0.00	0.00	0.0	0.00	0.00	0.0	
20	5.3	1.77	5.40	—0.1	3.13	3.71	+1.6	Mean of c=1.958 feet.
40	7.2	2.78	8.49	—1.3	7.73	9.17	—2.0	Mean of f=5.043 feet.
60	8.1	3.10	9.47	—1.4	9.61	11.39	—3.3	Mean depth=5.98 feet.
80	8.7	3.15	9.19	—0.5	9.92	11.76	—3.1	
100	9.0	3.15	9.19	—0.2	9.92	11.76	—2.8	Area of section = 1,557 square feet.
120	9.2	3.10	9.47	—0.3	9.61	11.39	—2.2	
140	9.0	2.78	8.49	+0.5	7.73	9.17	—0.2	
160	8.2	2.28	6.96	+1.2	5.20	6.17	+2.0	
180	6.5	1.52	4.64	+1.9	2.31	2.74	+3.8	
200	3.8	1.01	3.08	+0.7	1.02	1.21	+2.6	
220	2.1	0.59	1.80	+0.3	0.34	0.40	+1.7	
240	0.7	0.23	0.70	0.0	0.05	0.06	+0.6	
258	0.0	0.00	0.00	0.0	0.00	0.00	0.0	

No. 6.—*River section on M N.*

a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*	
Distance from right bank.	Depth.	V. in feet per second.	V. × coëf. 10.16.	*b*—*d*	V^2.	V^2. × coëf. 2.22.	*b*—*g*	Remarks.
Feet.	*Feet.*							
0	1.8	0.0	0.0	+ 1.8	0.0	0.00	+ 1.8	
100	11.1	0.96	9.7	+ 1.4	0.92	2.04	+ 9.1	
200	20.2	2.41	24.5	— 4.3	5.81	12.90	+ 7.3	
300	23.4	2.87	29.1	— 5.7	8.24	18.29	+ 5.1	
400	25.2	3.13	30.8	— 5.6	9.80	21.76	+ 3.4	
500	25.2	3.35	34.0	— 8.8	11.22	24.91	+ 0.3	
600	25.8	3.52	35.7	— 9.9	12.39	27.51	— 1.7	
700	26.7	3.67	37.3	—10.6	13.47	29.90	— 3.2	
800	28.9	3.83	38.9	—10.0	14.67	32.57	— 3.7	
900	31.4	3.96	40.2	— 8.8	15.68	34.81	— 3.4	
1,000	35.0	4.80	41.4	— 6.4	16.65	36.96	— 2.0	
1,100	37.5	4.22	42.9	— 5.4	17.81	39.54	— 2.0	
1,200	40.3	4.35	44.2	— 3.9	18.92	42.00	— 1.7	
1,300	42.1	4.45	45.2	— 3.1	19.80	43.96	— 1.9	
1,400	43.8	4.53	46.0	— 2.2	20.52	45.55	— 1.7	
1,500	46.5	4.64	47.1	— 0.6	21.53	47.79	— 1.3	
1,600	48.4	4.72	47.9	+ 0.5	22.28	49.46	— 1.1	
1,700	50.1	4.81	48.9	+ 1.2	23.14	51.37	— 1.3	
1,800	51.5	4.88	49.6	+ 1.9	23.81	52.85	— 1.3	
1,900	52.3	4.94	50.2	+ 2.1	24.40	54.16	— 1.9	
2,000	53.9	5.00	50.9	+ 3.0	25.00	55.50	— 1.6	
2,100	55.4	5.06	51.4	+ 4.0	25.60	56.83	— 1.4	
2,200	55.4	5.10	51.8	+ 3.6	26.01	57.74	— 2.3	
2,300	57.6	5.14	52.2	+ 5.4	26.42	58.65	— 1.0	
2,400	58.2	5.20	52.8	+ 5.4	27.04	60.02	— 1.8	
2,500	58.1	5.23	53.1	+ 5.0	27.25	60.63	— 2.5	
2,600	59.7	5.27	53.5	+ 6.2	27.77	61.64	— 1.9	
2,700	60.6	5.29	53.7	+ 6.9	27.98	62.11	— 1.5	
2,800	62.0	5.30	53.8	+ 8.2	28.09	62.36	— 0.4	
2,900	61.3	5.30	53.8	+ 7.5	28.09	62.36	— 1.1	
3,000	59.0	5.29	53.7	+ 5.3	27.98	62.11	— 3.1	
3,100	56.5	5.22	53.0	+ 3.5	27.25	60 63	— 4.1	
3,200	53.2	5.15	52.3	+ 0.9	26.52	58.87	— 5.7	
3,300	50.6	5.02	51.0	— 0.4	25.20	55.94	— 5.3	
3,400	49.6	4.87	49.5	+ 0.1	23.72	52.65	— 3.0	
3,500	48.5	4.65	47.2	+ 1.3	21.62	47.99	+ 0.5	Area of section =171,112 square feet.
3,600	46.1	4.36	44.3	+ 1.8	19.01	42.20	+ 3.9	
3,700	43.3	3.92	39.8	+ 3.5	15.37	34.12	+ 9.2	Mean depth, 42.9 feet.
3,800	37.0	3.29	33.4	+ 3.6	10.82	24.02	+13.0	
3,900	15.1	2.24	22.8	— 7.7	5.02	11.14	+ 4.0	
3,980	1.8	0.00	0.0	+ 1.8	0.00	0.00	+ 1.8	

O 1.

A REPORT UPON COMPARISON OF SURVEYS, MISSISSIPPI RIVER, BY HENRY L. MARINDIN, UNITED STATES COAST AND GEODETIC SURVEY.

BOSTON, MASS., *April* 22, 1880.

SIR: A comparison of surveys of that part of the Mississippi River lying between the Head of Passes, Louisiana, and a line across the river about 4,000 feet above the north point of "Cubitt's Gap," has just been completed, and I have the honor to forward it in accordance with your call of April 12, 1880.

Beginning at a line 4,000 feet about the north point of "Cubitt's Gap," to a line across the river at the south point, we have two surveys for comparison, both by the Coast Survey—one in 1872 by Assistant Granger, and the other in 1876 by a party under my charge. This comparison shows a shoaling on both banks of the stream, and a marked deepening along the center of the river, and towards the right bank—west shore. Taking the whole area under consideration, there has been a deepening of 1.7 feet in the four years, or 0.4 foot per year, in that part of the river above the "gap;" and a mean shoaling of 0.5 foot in the same time, or 0.12 foot per year, in that part of the river directly in front of the "gap."

A noticeable feature in front of the "gap" and one which in a great measure must be traced to it as its cause, is the formation of a flat on the west bank, as shown by the deep contours—the 24-foot curve more especially. Starting at a point on the west shore, 3,000 feet above the "gap," where all the curves run parallel to the shore, and the 24-foot curve is 260 feet from the 3-foot curve, which I have taken as the reference for convenience, being smoother than the shore line, although running parallel to it, the 24-foot contour abruptly juts out towards the center of the river, till opposite the north point of the "gap" it is 820 feet from the 3-foot curve; then following down stream and opposite the south point it is 920 feet; then after passing the opening of "Cubitt's Gap" it retreats towards the shore line, so that about 2,000 feet below the south point it is 760 feet, 4,000 feet below it is 720 feet off, and 8,000 feet below the "gap" it is only 500 feet off, notwithstanding the gradual expansion of the Mississippi, which at the upper limit is 3,720 feet wide, and at the lower limit, 8,000 feet below the "gap," it is 4,815 feet in width, as measured between the 3-foot curve of each bank.

From the south point, for a distance of about 1,300 feet down stream, the two surveys compared are one of 1866 and the other 1876, which give a mean shoaling of 1.6 feet in the ten years, or 0.16 foot per year.

From the above-mentioned limit, 1,300 feet below the south point of "gap," to Cubitt's House, we have two surveys for comparison—one executed in 1866 by Assistant Gerdes and the other by my party in 1877, giving an interval of eleven years; over this space there has been a mean shoaling of 3.9 feet, or 0.35 foot per year.

From Cubitt's House to the Head of the Passes, including all the space now covered by the works for the improvement of the channel way into South Pass, we have two surveys again—one of 1866, by Assistant Gerdes, and one done under my direction in 1875, by Subassistant Braid. These surveys show a decrease in depth of 3.6 feet in nine years, or 0.4 foot each year. Where, however, the present jettied channel into South Pass is located there had been a decided deepening.

The accompanying Table 1 gives the comparison of the different surveys in detail, by dividing the surface of the river into squares of 10″ latitude by 10″ longitude, and giving the mean depth in that area as obtained by the sum of all the soundings over this space.

Table 2 gives the position of the flat in front of "Cubitt's Gap," as delineated by the 24-foot contour, with a reference also to the width of the river at that place.

Table 3 gives a cross-section of the river at the south point of "Cubitt's Gap." This section begins at the west shore, and follows one of the sounding lines of the survey of 1866, and is compared to the survey of 1876. It lies somewhat diagonally across the stream. The comparison shows an average shoaling of 1.2 feet in ten years, or 0.12 per year—a decrease in depth of 3 per cent.

Table 4 gives a cross-section of the river about 1¾ miles below "Cubitt's Gap." This shows a mean shoaling between 1866 and 1877 of 3.4 feet, or 0.31 foot per year—a decrease of 10 per cent.

Table 5 gives another section across the wide part of the river, at the Head of Passes, at a point below Cubitt's House. It begins on the west shore and runs on a line of soundings of the survey of 1866, and is compared to the survey of 1875; the section ends at the east shore, near the south end of the Mississippi base. This section shows a decrease in depth of 4.4 feet in nine years, or 0.48 foot per year, a decrease of nearly 17 per cent.

There is no change in the width of the river between Cubitt's Gap and the Passes, as shown by the 3 and 6 foot curve, although the bed of the stream shows a slight bodily shift to the eastward.

In all cases during this comparison where the soundings of the earlier surveys—which are not as numerous as in the more recent surveys—fell between close lines of soundings, the comparative depth was obtained by grouping the surrounding soundings of the later survey.

A sketch of the locality, showing the areas covered by the comparison, is appended.

Respectfully submitted.

HENRY L. MARINDIN,
Assistant, Coast and Geodetic Survey.

Hon. CARLISLE P. PATTERSON,
Superintendent of Coast and Geodetic Survey, Washington, D. C.

TABLE 1.—*Mississippi River—Comparison of Surveys at Head of Passes, Louisiana, of* 1866 1872, 1875, 1876, 1877.

Area limits.						Mean depth.		Mean amount.		Per cent. of depth.	Remarks.
Latitudes.			Longitudes.			1866.	1875.	Shoaled.	Deepened.		
°	′	″	°	′	″	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
		40			10						
29	08	50	89	14	20	25.7	20.6	— 5.1	.....	—19	At head of Passe à l'Outre.
					20						
					30	25.0	19.7	— 5.3	.. ....	—21	
					30						
					40	14.6	20.0	— 2.6	.....	—18	
					40						
					50	14.7	14.2	— 0.5	.....	—03	
					50						
				15	00	12.5	14.8	.. ....	2.3	18	
					00						
					10	14.0	14.9	.....	0.9	06	
					10						
					20	31.4	23.5	— 7.9	.....	—25	
					20						
					30	34.7	33.1	— 1.6	.....	—04	
					30						
					40	16.0	15.0	— 1.0	.....	—06	Head of Southwest Pass, west shore.
	29	08	50			10					
		09	00	89	14	20	31.0	27.0	— 4.0	.....	—13	At head of Passe à l'Outre.
						20					
						30	26.0	19.0	— 7.0	.....	—27	
						30					
						40	22.6	17.8	— 4.8	.....	—21	
						40					
						50	22.5	16.5	— 6.0	.....	—26	
						50					
					15	00	17.6	16.6	— 1.0	.....	—06	
					15	00						
						10	27.0	22.2	— 4.8	.....	—18	
						10						
						20	30.6	26.0	— 4.6	.....	—15	
						20						
						30	30.2	27.9	— 2.3	.....	—07	
						30						
						40	.....	.....	.....	.....	.....	At west shore.
		00				10						
29	09	10	89	14	20	32.4	26.9	— 5.5	.....	—17	At head of Passe à l'Outre.
						20						
						30	33.1	23.4	— 9.7	.....	—29	
						30						
						40	24.2	18.6	— 5.6	.....	—23	
						40						
						50	25.5	21.1	— 4.4	.....	—17	
						50						
					15	00	27.7	21.7	— 6.0	.....	—21	
						00						
						10	27.0	22.0	— 5.0	.....	—18	
						10						
						20	30.5	27.1	— 3.4	.....	—11	
						20						
						30	26.8	27.0	.....	0.2	01	
						30						
						40	22.1	21.3	— 0.8	.....	—03	
						40						
						50	.....	.....	.....	.....	.....	At west shore.
		10				10						

TABLE 1.—*Comparison of Surveys at Head of Passes, Louisiana, &c.*—Continued.

Area limits.						Mean depth.		Mean amount.		Per cent. of depth.	Remarks.
Latitudes.			Longitudes.			1866.	1875.	Shoaled.	Deepened.		
°	′	″	°	′	″	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
29	09	20	89	14	20	23.8	22.2	— 1.6	.....	—07	At east shore.
		10			20						
29	09	20	89	14	30	29.2	25.8	— 3.4	.....	— 11	
					30						
					40	29.6	23.8	— 5.8	.....	— 19	
					40						
					50	24.3	22.6	— 1.7	.....	— 07	
					50						
				15	00	29.9	23.2	— 6.7	.....	— 23	
				15	00						
					10	33.8	26.7	— 7.1	.....	— 21	
		20			20						
29	09	30	89	14	30	18.7	17.1	— 1.6	.....	— 09	At east shore.
					30						
					40	25.4	25.4	— 0.0	0.0	.....	
					40						
					50	29.5	26.0	— 3.5	.....	— 12	
						1866.	1877.				
		10			10						
29	09	20	89	15	20	33.9	27.6	— 6.3	.....	— 18	
					20						
					30	31.2	26.5	— 4.7	.....	— 15	
					30						
					40	.....	.....	.....	.....	.....	
					40						
					50	.....	.....	.....	.....	.....	At west shore.
		20	89	14	50						
29	09	30		15	00	28.7	26.9	— 1.8	.....	— 06	
					00						
					10	37.4	28.6	— 8.8	.....	— 23	
					10						
					20	37.0	28.6	— 8.4	.....	— 22	
					20						
					30	33.0	27.6	— 5.4	.....	— 16	
					30						
					40	31.6	25.9	— 5.7	.....	— 18	
					40						
					50	16.3	8.8	— 7.5	.....	— 45	At west shore.
		30			30						
29	09	40	89	14	40	18.7	17.9	— 0.8	.....	— 04	At east shore.
					40						
					50	29.0	26.6	— 2.4	.....	— 08	
					50						
				15	00	28.5	27.3	— 1.2	.....	— 04	
					00						
					10	34.4	29.2	— 5.2	.....	— 15	
					10						
					20	39.7	31.1	— 8.6	.....	— 21	
					20						
					30	38.0	29.3	— 8.7	.....	— 22	
					30						
					40	.....	.....	.....	.....	.....	
					40						
					50	.....	.....	.....	.....	.....	At west shore.
29	09	50	89	14	40	.....	.....	.....	.....	.....	At east shore, near Cubitt's house.
					40						
					50	23.9	24.2	.....	0.3	01	
					50						
				15	00	33.2	27.5	— 5.7	.....	— 17	
					00						
					10	34.9	31.2	— 3.7	.....	— 10	
					10						
					20	41.1	34.4	— 6.7	.....	— 16	
					20						
					30	42.7	32.2	—10.5	.....	— 24	
					30						
					40	33.4	28.3	— 5.1	.....	— 15	
					40						
					50	28.4	23.5	— 4.9	.....	— 17	
					50						
				16	00	.....	.....	.....	.....	.....	At west shore.
29	09	50			40						

TABLE 1.—*Comparison of Surveys at Head of Passes, Louisiana, &c.*—Continued.

Area limits.						Mean depth.		Mean amount.		Percent. of depth.	Remarks.
Latitudes.			Longitudes.			1866.	1877.	Shoaled.	Deepened.		
°	′	″	°	′	″	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
29	10	00	89	14	50	.....	.....	.....	.....	.....	At east shore.
					50						
				15	00	27.0	25.4	— 1.6	.....	— 06	
					00						
					10	33.7	31.2	— 2.5	.....	— 07	
					10						
					20	40.3	35.5	— 4.8	.....	— 11	
					20						
					30	43.5	36.4	— 7.1	.....	— 16	
					30						
					40	.....	.....	.....	.....	.....	
					40						
					50	30.0	27.2	— 2.8	.....	— 09	
					50						
				16	00	.....	.....	.....	.....	.....	At west shore.
		00	89	14	50						
29	10	10		15	00	25.0	25.0	— 0.0	0.0	.....	At east shore.
					00						
					10	27.0	27.0	— 0.0	0.0	.....	
					10						
					20	40.5	33.0	— 7.5	.....	— 18	
					20						
					30	43.7	38.2	— 5.5	.....	— 12	
					30						
					40	45.3	35.3	—10.0	.....	— 22	
					40						
					50	33.4	28.7	— 4.7	.....	— 13	
					50						
				16	00	25.5	22.0	— 3.5	.....	— 13	At west shore.
		10			00						
29	10	20	89	15	10	28.4	28.1	— 0.3	.....	— 01	At east shore.
					10						
					20	36.5	32.5	— 4.0	.....	— 11	
					20						
					30	39.2	38.2	— 1.0	.....	— 02	
					30						
					40	46.7	40.3	— 6.4	.....	— 13	
		10			40						
29	10	20	89	15	50	42.0	32.0	—10.0	.....	—23	
					50						
				16	00	32.0	26.4	— 6.6	.....	—20	At west shore.
		20			10						
29	10	30	89	15	20	29.6	30.5	.....	0.9	03	At east shore.
					20						
					30	40.0	38.0	— 2.0	.....	—05	
					30						
					40	45.4	42.0	— 3.4	.....	—07	
					40						
					50	47.0	39.0	— 8.0	.....	—17	
					50						
				16	00	38.0	30.1	— 7.9	.....	—20	
					00						
					10	28.2	21.2	— 7.0	.....	—24	At west shore.
		30			10						
29	10	40	89	15	20	21.8	24.0	.....	2.2	10	At east shore.
					20						
					30	33.5	34.6	.....	1.1	03	
					30						
					40	.....	.....	.....	.....	.....	
					40						
					50	48.0	45.3	— 2.7	.....	—05	
					50						
				16	00	45.4	36.0	— 9.4	.....	—20	
					00						
					10	34.9	24.1	—10.8	.....	—30	At west shore.
		40			20						
29	10	50	89	15	30	24.0	29.9	.....	5.9	24	At east shore.
					30						
					40	39.0	38.6	— 0.4	.....	—01	
					40						
					50	45.6	46.0	.....	0.4	01	
					50						
				16	00	46.1	43.1	— 3.0	.....	—06	
					00						

TABLE 1.—*Comparison of Surveys at Head of Passes, Louisiana, &c.*—Continued.

Area limits.						Mean depth.		Mean amount.		Percent. of depth.	Remarks.
Latitudes.			Longitudes.			1866.	1877.	Shoaled.	Deepened.		
°	′	″	°	′	″	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
20	10	50	89	16	10	39.6	29.6	—10.0	.....	—25	
					10						
					20	31.6	23.0	— 8.6	.....	—27	At west shore.
29	10	00			30						
	11	00	89	15	40	32.6	34.7	.....	2.1	06	At east shore.
					40						
					50	43.0	43.8	.....	0.8	02	
					50						
				16	00	47.0	48.0	.....	1.0	06	
					00						
					10	.....	.....	.....	.....	.....	
					10						
					20	34.0	25.0	— 9.0	.....	—26	At west shore.
29	11	10	89	15	40	17.7	25.3	.....	7.6	42	At east shore.
					40						
					50	35.8	38.7	.....	2.9	07	
					50						
				16	00	44.8	47.7	.....	2.9	06	
					00						
					10	47.6	45.5	— 2.1	.....	—04	
					10						
					20	36.0	25.6	—10.4	.....	—28	
					20						
					30	24.0	14.8	— 9.2	.....	—38	At west shore.
		10			40						
29	11	20	89	15	50	27.5	33.0	.....	5.5	20	At east shore.
					50						
				16	00	41.0	45.0	.....	4.0	09	
					00						
					10	44.0	51.5	.....	7.5	17	
					10						
					20	45.6	35.2	—10.4	.....	—22	
					20						
					30	32.6	22.5	—11.1	.....	—34	
					30						
					40	26.0	15.3	—10.7	.....	—41	At west shore.
						1866.	1876.				
		20	89	15	50						
29	11	30		16	00	.....	.....	.....	.....	.....	At east shore.
					00						
					10	43.5	48.2	.....	4.7	10	
					10						
					20	41.1	49.3	.....	8.2	20	
					20						
					30	40.2	29.8	—10.4	.....	—25	
					30						
					40	27.8	17.8	—10.0	.....	—36	At west shore opposite Cubitt's Gap.
						1872.	1876.				
		30	89	15	50						
29	11	40		16	00	32.4	33.4	.....	1.0	03	East shore below South Point of Cubitt's Gap.
					00						
					10	44.5	47.0	.....	2.5	05	
					10						
					20	43.3	50.3	.....	7.0	16	
					20						
					30	45.0	48.0	.....	3.0	06	
					30						
					40	38.0	33.0	— 5.0	.....	—13	
					40						
					50	.....	.....	.....	.....	.....	At west shore.
		40			00						
29	11	50	89	16	10	.....	.....	.....	.....	.....	Near edge of Cubitt's Gap.
					10						
					20	.....	.....	.....	.....	.....	
					20						
					30	49.3	53.5	.....	4.2	08	
		40			30						
29	11	50	89	16	40	43.2	39.0	— 4.2	.....	—09	
					40						
					50	26.5	22.7	— 3.8	.....	—14	At west shore.

TABLE 1.—*Comparison of Surveys at Head of Passes, Louisiana, &c.*—Continued.

Area limits.						Mean depth.		Mean amount.		Per cent. of depth.	Remarks.
Latitudes.			Longitudes.			1872.	1876.	Shoaled.	Deepened.		
°	′	″	°	′	″	*Feet.*	*Feet.*	*Feet.*	*Feet.*		
29	11	50	89	16	10						
	12	00			20	48.3	51.6	— 3.3	.....	—06	At edge of Cubitt's Gap.
					20						
					30	55.0	55.0	0.0	0.0	.....	
					30						
					40	.....	.....	.....	.....	.....	
					40						
					50	42.0	37.1	— 4.9	.....	—11	
					50						
				17	00	.....	.....	.....	.....	.....	West shore, opposite, north point of gap.
		00			20						
29	12	10	89	16	30	.....	.....	.....	.....	.....	Above north point of gap, east shore.
					30						
					40	50.4	53.0	.....	2.6	05	
					40						
					50	.....	.....	.....	.....	.....	
					50						
				17	00	.....	.....	.....	.....	.....	At west shore.
		10			20						
29	12	20	89	16	30	48.0	45.3	— 2.7	.....	—05	At east shore.
					30						
					40	57.0	55.2	— 1.8	.....	—03	
					40						
					50	48.0	47.3	— 0.7	.....	—01	
					50						
				17	00	36.7	38.8	.....	2.1	—05	
					00						
					10	25.2	23.0	— 2.2	.....	—08	At west shore.
		20			20						
29	12	30	89	16	30	27	39.0	.....	12.0	44	At east shore.
					30						
					40	51	54.0	.....	3.0	05	
					40						
					50	56.6	58.3	.....	1.7	03	
					50						
				17	00	43.6	49.2	.....	5.6	12	
					00						
					10	32.8	31.5	— 1.3	.....	—04	
					10						
					20	.....	.....	.....	.....	.....	At west shore.
		30			30						
29	12	40	89	16	40	.....	.....	.....	.....	.....	At east shore.
					40						
					50	55.5	57.6	.....	2.1	03	

TABLE 2.—*Outline of flat opposite "Cubitt's Gap," as shown by the 24-foot curve of west shore.*

Distance along 3-foot curve of west shore.	Distance of 24-foot curve from 3-foot curve.	Width of river.	Remarks.
Feet.	*Feet.*	*Feet.*	
0	260	3,720	The 24-foot curve parellel to shore, 3,000 feet above "gap."
2,000	535	3,870	
4,000	820	.....	Opposite to Cubitt's Gap.
6,000	920	4,050	Opposite to south point of gap, nearly. About 1,700 feet below gap.
8,000	760	4,110	
10,000	720	4,215	
12,000	520	4,485	
14,000	500	4,815	

NOTE.—The 3-foot curve, running parellel to the shore line, but much smoother, was taken as the base from which the ordinates to the 24-foot curve were measured.

TABLE 3.—*Mississippi River—section from right bank (west shore) to east bank below south point "Cubitt's Gap," in* 1866 *and* 1876, *A to B.*

Distance from shore line.	Depth in feet at low water.		Amount shoaled or deepened.		Remarks.
	1866.	1876.	In ten years.	Ratio to depth.	
Feet.	*Feet.*	*Feet.*	*Feet.*	*Per cent.*	
0	4	0	− 4	−100	Lat. 29° 11′ 21″.7; long. 89° 16′ 40″. Shore line of 1876 at west shore.
150	11	1	−10	− 90	
350	15	20	5	33	The section begins at west shore and runs somewhat diagonally downward across the stream on a line of soundings of survey of 1866, and ends about 960 feet below the south point of Cubitt's Gap.
500	36	22	−14	− 38	
720	37	23	−14	− 37	
920	40	23	−17	− 42	
1,080	30	24	− 6	− 20	
1,200	36	25	− 9	− 25	
1,360	43	30	−13	− 29	
1,530	46	35	−11	− 24	
1,720	46	40	− 6	− 13	
1,950	42	38	− 4	− 09	
2,100	39	49	10	25	
2,230	36	50	14	39	
2,425	40	51	11	27	
2,610	40	51	11	27	
2,810	43	49	6	14	
2,970	42	47	5	12	
3,150	42	49	7	18	
3,340	45	50	5	11	
3,470	46	46	0	0	
3,640	45	44	− 1	− 02	
3,790	42	41	− 1	− 02	
3,920	39	39	0	0	
4,050	34	38	4	12	
4,190	30	31	1	03	
4,310	17	18	1	05	
4,425	1	0	− 1	−100	Lat. 29° 11′ 35″.1; long. 89° 15′ 53″.6. Shore line of 1876 at east shore'

TABLE 4.—*Mississippi River—section from right to left bank, about* $1\frac{3}{4}$ *miles below Cubitt's Gap, Louisiana, E to F.*

Distance from shore line.	Depth in feet at low water.		Amount shoaled or deepened.		Remarks.
	1866.	1877.	In eleven years.	Ratio to depth.	
Feet.	*Feet.*	*Feet.*	*Feet.*	*Per cent.*	
0	.....	.....	.....	.....	Lat. 29° 10′ 10″.9; long. 89° 16′ 03″.8. Shore line of 1877 west shore
130	1	1	0	.....	
250	5	6	1	20	
380	25	22	− 3	−12	
540	31	23	− 8	−25	
770	33	24	− 9	−27	
950	34	26	− 8	−23	
1,110	33	29	− 4	−12	
1,310	39	29	−10	−25	
1,470	43	32	−11	−25	
1,620	45	33	−12	−26	
1,830	45	34	−11	−24	
1,970	46	36	−10	−21	
2,170	48	38	−10	−20	
2,375	49	39	−10	−20	
2,580	48	39	− 9	−19	
2,770	46	42	− 4	−08	
2,950	43	43	0	.....	
3,220	42	41	− 1	−02	
3,455	40	40	0	.....	
3,660	39	36	− 3	−07	
3,850	36	36	0	.....	
4,070	36	34	− 2	−06	
4,290	34	34	0	.....	
4,540	33	31	− 2	−06	
4,750	29	29	0	.....	
4,900	22	28	6	27	
5,100	13	27	14	108	
5,230	3	14	11	360	
5,400	0	.....	.....	.....	Lat. 29° 10′ 25″.7; long. 89° 15′ 05″.5. Shore line of 1877 east shore.

TABLE 5.—*Mississippi River—section at Head of Passes, about 2,342 feet above Head of Passes light-house, west shore to east shore, C to D.*

[The sign — signifies decrease in depth. Absence of sign signifies increase in depth.]

Distance from shore line.	Depth in feet at low water.		Amount shoaled or deepened.		Remarks.
	1866.	1875.	In nine years.	Ratio to depth.	
Feet.	*Feet.*	*Feet.*	*Feet.*	*Per cent.*	
0	.....	.....	.....	.....	Lat. 29° 08′ 45″.1; long. 89° 15′ 41″.0. Shore line of 1875 at west shore. This section follows one of the cross-section sounding lines of survey of 1846, starting on west shore and ending at east shore near south end of Mississ ppi base.
144	2	2	0	0	
308	4	3	— 1	— 25	
436	5	5	0	0	
580	9	12	3	33	
698	27	27	0	0	
862	31	27	— 4	— 13	
1,007	34	28	— 6	— 17	
1,175	33	29	— 4	— 12	
1,328	33	29	— 4	— 12	
1,502	34	28½	— 5½	— 15	
1,673	31	28½	— 3½	— 11	
1,847	33	28½	— 4½	— 13	
2,040	30	27	— 3	— 10	
2,224	31	27½	— 3½	— 11	
2,402	31	26	— 5	— 16	
2,575	31	26	— 5	— 16	
2,756	33	26	— 7	— 21	
2,953	33	27	— 6	— 18	
3,126	31	24	— 7	— 22	
3,297	30	23	— 7	— 23	
3,477	29	24	— 5	— 17	
3,655	27	22	— 5	— 18	
3,871	27	22	— 5	— 18	
4,052	27	23	— 4	— 15	
4,193	28	22	— 6	— 21	
4,380	30	20½	— 9½	— 31	
4,600	30	21	— 9	— 30	
4,796	30	21	— 9	— 30	
4,973	30	21½	— 8½	— 28	
5,170	28	21	— 7	— 26	
5,348	28	21	— 7	— 26	
5,521	27	22	— 5	— 18	
5,685	26	22	— 4	— 15	
5,905	23	22½	— 0½	— 02	
6,050	28	23	— 4	— 15	
6,220	27	23	— 5	— 18	
6,398	30	23	— 7	— 23	
6,549	31	23	— 8	— 25	
6,732	31	25	— 6	— 20	
6,890	31	26	— 5	— 16	
7,038	31	25	— 6	— 20	
7,172	31	25½	— 5½	— 17	
7,326	27	25½	— 1½	— 05	
7,529	33	24½	— 9	— 27	
7,690	31	26	— 5	— 16	
7,808	27	21	— 6	— 22	
7,979	7	14	7	100	
8,123	4	5	1	25	
8,242	2	1¾	— 0¼	— 12	
8,350	0	0	0	— 0	Lat. 29° 09′ 24″.8; long. 89° 14′ 18″.4. Shore line of 1875 east shore.

APPENDIX P.

A REPORT ON THE BLUE CLAY OF THE MISSISSIPPI RIVER, BY GEORGE LITTLE, PH. D.

ATLANTA, GA., *July* 4, 1880.

DEAR SIR: In accordance with your letter of instructions, I have made, during the months of February, March, and December of last year, a "'study and report on the so-called, blue-clay' problem of the Mississippi River." As you have expressed the special question to be: "Is this formation one ante-dating geologically the present river, and into which the river has dug a bed; or is it a deposit by the river itself, in which has formed its own bed, as in the case of the 'Passes'?" I have made a careful examination of the geological formations from Memphis to New Orleans, and pre-

sent herewith sections, thirty-three in number, of all the prominent exposures or outcrops, either made by myself or competent observers, viz:

Sir Charles Lyell, second visit to the United States.
David Dale Owen, State geologist of Arkansas.
Eugene W. Hilgard, State geologist of Mississippi.
James M. Safford, State geologist of Tennessee.
Eugene A. Smith, State geologist of Alabama.
F. V. Hopkins, State geologist of Louisiana.

For a more thorough knowledge of the river and its history, I have studied the—

Report on the Mississippi River. Humphreys and Abbot, 1876.
Report on the Mississippi and Ohio Rivers. Charles Ellet.
Geological Description of Louisiana. William Darby.
Géologie Practique de Louisiane. R. Thomassy.
Silliman's Journal, E. W. Hilgard; March, April, May, 1871, on Geology of the Delta and Mud Lumps of the Passes.

Report on the Rock Salt Deposit of Petit Anse; of the American Bureau of Mines, by Chas. Goessman.

Smithsonian Contributions to Knowledge, No. 248, on the Geology of Lower Louisiana. Eugene W. Hilgard.

Reports upon the specimens obtained from borings made in 1874, between the Mississippi River and Lake Borgne, to Engineer Department United States Army, by Prof. E. W. Hilgard, and Dr. F. V. Hopkins, 1878.

The Physics of the Gulf of Mexico and its Chief Affluent, the Mississippi River, by Caleb G. Forshey, New Orleans, Louisiana, 1878.

Improvement of the Mississippi River and its Alluvial Lands, Mis. Doc. No. 13, House of Representatives, Forty-fifth Congress, Third Session. Memorial of John Cowden, January, 1879.

Dr. W. J. Carroll's new theory in that branch of natural science, known as River Hydraulics, Natchez, 1878.

Official Register, Louisiana State University, 1870–'71–'72–'77, in which reports are made by Profs. F. V. Hopkins and S. H. Lockett.

Special report of the Board of State Engineers to the governor of Louisiana on the mouth of Red River, and the Falls at Alexandria, January 23, 1874, New Orleans, by E. H. Angamar, and M. Jeff. Thompson.

Reconnaissance Mississippi River, Cairo to New Orleans, to accompany third subdivision Mississippi Route to the Seaboard. Act Congress June 23, 1874, by Maj. Charles R. Suter.

Map Mississippi River, between mouths of the Illinois and Ohio, 1870. By Col. James H. Simpson, U. S. A.

Map Mississippi River between Cairo and New Orleans.
Report on Geology of Missouri. G. C. Swallow.
Report on Geology of Arkansas. D. D. Owen.
Report on Geology of Tennessee. J. M. Safford, 1860.
Report on Geology of Mississippi. B. L. C. Wailes, 1854.
Report on Geology of Mississippi. E. W. Hilgard, 1860.
Report on Geology of Louisiana. F. V. Hopkins, 1870–'71–'72–'77.
Report on Geology of Alabama. M. Tuomey, 1850 and 1858.
Report on Geology of Illinois. A. C. Worthen.
Report on Geology of Iowa. C. A. White.

The history of the Mississippi River affords an epitome of the history of that portion of the continent embraced within the United States. Its headwaters rise in the oldest Azoic rocks, near the line of British America, from the springs and lakes of Minnesota, and its affluents drain the western slope of the Appalachian water-shed, as well as the eastern side of the Rocky Mountains.

It has excavated its bed through the Palaeozoic rocks of Wisconsin, Iowa, Illinois, Missouri, and Kentucky. Its banks in these States are mostly composed of sandstone and limestone, which have confined the waters to a comparatively narrow channel. But below the mouth of the Ohio, in latitude 36° 58′, and indeed above, at Cape Girardeau, in latitude 37° 20′, softer material allows the stream greater latitude, and we find that, as soon as the Cretaceous and Tertiary rocks begin to appear, the river has at different times spread out over a much wider area.

From Cairo, in latitude 37° 00′, to the Gulf of Mexico, in latitude 29° 00′, the successive elevations of the continent have brought to the surface the rocks of different periods in Mesozoic and Cenozoic times, in regular arrangement with the mouth of the Mississippi River as a center, in approximately concentric circles; or, perhaps, more accurately stated, as the sides of a triangle whose apex is near Cairo, in latitude 37° 00′, and whose base is the Gulf shore, in about latitude 29° 00′. Thus we find the *Cretaceous* rocks extending from the vicinity of Cairo southeastward to Alabama and Georgia, where they terminate on the east side of the Mississippi, and through Arkansas to and through Texas on the west side.

The *Tertiary* rocks extend next to these on both sides of the river and border the Mississippi bottom, or lands subject now to overflow, as far south as Chicot, Ark., in latitude 33° 00′, on the west, and Fort Adams, Mississippi, in latitude 31° 05′, on the east side of the river.

The *Quarternary* clays border the Gulf from these points southward, and are said to extend some distance beneath the waters of the Gulf as sea bottom before the deep water sets in. Immediately beneath these clays, but overlying the Cretaceous and Tertiary rocks we find an extensive deposit of sand and pebbles, extending from Cairo to the Gulf, which corresponds in geological time with the Great Drift period of the States north of the Ohio, and which probably resulted from the melting of the glaciers which strewed the bowlders and deposited the clays and sands over the surface of the Northern States.

The rounded forms of these pebbles and sand grains indicate their removal by a rapid flowing current. By their grinding action, as well as the force of the current which bore them along, a deep basin has been cut out in the rocks of Cretaceous and Tertiary age from Cairo to the Gulf, and this basin has afterwards been filled above the gravel and pebbles which covered its bottom, by two distinct materials—the lower one, a stiff clay, formed in still water; the upper, a fine silt, which shows no evidence of stratification, and must have been deposited from water free from any appreciable current. While the clay has only been recognized as far north as Columbus, Ky, in latitude 36° 47′, the silt, or Loess, has been traced as far as Sioux City, Iowa, in latitude 42° 33′, and nearly to Fort Pierre, Dak., in latitude 44° 23′, of uniform texture and chemical composition, and with physical features so similar that specimens from Sioux City cannot be distinguished by the eye from those found in the bluff at Fort Adams, in latitude 31° 05′, or Baton Rouge, in latitude 30° 27′, where this stratum terminates to the southward.

While the Mississippi River was filling up with calcareous silt the wide bed eroded by the glacial stream, there was forming around the coast of the Gulf a a marshy deposit of blue clay, which is now exposed at Port Hudson, on the Mississippi River, in latitude 30° 40′, and eastward to Mobile, and westward from Chicot to Victoria, Tex. These seem to have been closely related, though successive deposits from the fact that, at the characteristic outcrop at Port Hudson the calcareous silt is replaced by a yellowish, sandy hard-pan with no perceptible line of separation, while lower down at Garig's Ferry on the Amite River, near the junction of the Comite, the hard-pan becomes whitish and more clayey, and lower down again passes gradually into a light-blue sandy clay, which represents the blue clay found in the banks of the Mississippi and as far eastward as Woodville, about twenty miles from Fort Adams.

In the sections made between Lake Borgne and the Mississippi River an alternation of sands and clay takes place, just such as we see now during a single season of high and low water on the river—sands and clays deposited alternately, according to the rapidity or slowness of the current.

A subsequent elevation of the southern portion of the Mississippi Valley has caused the river to make a new bed, cutting down into the silt, and in the course of ages it has removed again this light material, excepting a narrow strip along the bluff now bordering the "bottom" from Memphis, in latitude 35° 09′, along the edge of the Yazoo "bottom" to Vicksburg, Natchez, and Baton Rouge, in latitude 30° 27′ on the west, and Crowley's Ridge from the Missouri line, in latitude 36° 00′, to Helena, in latitude 34° 32′, and some isolated spots, such as Sicily Island, in Louisiana. The river has diminished in volume until at present it only occupies a bed about one mile in width, which is constantly changing, and may have moved its location from one side to the other of its basin, originally forty miles in width at Memphis. The melting of the snow on the Rocky Mountains, together with the accumulated water from the winter rains, causes it to overflow its present banks, and there is an annual deposit of alluvium extending from the banks across to the bluffs or highlands, which border what is known as the "Mississippi Bottom." This alluvial deposit varies with the material brought down by the current, but is generally sand or clay. The clay is sometimes blue, sometimes green; and again, as along Red River and below, it is red.

Although there is so great a difference in the tenacity of the clay and the sand, the power of the current of the river is such that it seems to cut them with equal ease in changing its bed, by washing out the lower strata of sand, and undermining the banks, so that acres often fall into the stream at once. Within the last twenty years, under my own observation, the river has cut away a mile of one bank and made a deposit of a mile on the opposite side, now overgrown with willow and poplar.

At Rodney, in latitude 31° 52′, where I landed from a steamer by a plank into a store in 1860, a sand-bar has formed, making the landing two miles from the same store in 1880. Not many years have passed since boats landed at the foot of the bluff on which Vicksburg stands. Last year the city had two miles' travel between it and

the river landing, and a batture formed in front of the old landing fully a mile in width.

At another point I have seen a small ditch dug across a narrow neck of land half a mile wide, which connected the points at which the river had approached itself at the extremes of a bend twenty-seven miles in length, and during one overflow the current began passing through this ditch, and before the river fell again a passage had been formed large enough to carry the largest steamers. This is now the main bed of the river, while the two ends of the bend have been silted up so as to form a lake twenty-five miles in length and crescent-shaped. Similar changes have happened repeatedly within the recollection of those now living, so that we may easily believe that if the bed has been changed nine miles from west to east in ten years, it may have moved forty in any half century, and thus passed from one side of the "bottom" to the other.

The materials of the banks from Memphis southward are mostly the clays and marls of the Tertiary until we reach Vicksburg on the eastern side, where a bed of Tertiary limestone has checked the current; and, again, at Grand Gulf, in latitude 32° 02′, we find a Grand Gulf sandstone, which has caused another curve in the course of the river.

At Fort Adams, in latitude 31° 05′, a claystone has again offered an obstacle to its free flow and turned it westward. On the west side it has had free course, unless the limestone outliers of the Cretaceous ridge, extending from Northern Louisiana to the Five Islands on the Gulf, may have offered an obstruction. The whole Mississippi Bottom appears at present to be uniform in its composition, consisting of alternating deposits of sand, where the currents were swift, and of beds of clay, which have filled the low places when the current was sluggish or in eddies. The alluvium in this respect resembles the other groups of the Quaternary period, as may be seen by the sections exposed in Alabama, as described by Tuomey; in Tennessee, as described by Safford; in Mississippi, by Hilgard; in Arkansas, by Owen, and by Hopkins, in Louisiana.

SOUTHERN DRIFT.

The stratum marking the division between the ancient history of the Mississippi and the modern is that composed of sand and pebbles, which is found all along the banks from the mouth of the Ohio, where we may suppose the old river entered the sea at the close of Carboniferous time, to the mouth of the Atchafalaya, at the Gulf where the new bed was cut out at the time the coast of the Gulf of Mexico had acquired nearly its present outline. While we find this stratum along the present course of the river, and along the border of the Carboniferous rocks, both east and west of the river, made up of pebbles of various sizes, the general surface of the Cretaceous and Tertiary is covered mostly by fine sand. Tuomey, in his first report on Alabama, 1850, described these deposits on the edge of the Carboniferous, and southward, as "superficial beds," as follows, page 159:

"I have in the preceding pages referred to beds of loose materials composed of pebbles, sand, clay, and loam, that are found over the State, often completely hiding the underlying rocks. These may be studied to great advantage around Tuscaloosa, where they are fairly displayed on the slope of the hill toward the river, affording a striking illustration of the causes that are daily modifying the earth's surface. The upper bed is composed of red loam, and is underlaid by yellow and white sand, showing oblique lamination. These beds alternate with deposits of coarse quartzose pebbles of various colors; among these are often found agate, jasper, hornstone, and other varieties of quartz. The largest of the pebbles rarely exceed four inches in diameter. Occasionally rounded fragments of the sandstone of the coal measures may be detected; and, in a few instances, I have found pieces of the millstone grit much larger than the pebbles. But the most interesting portion of these materials consist in the cherty pebbles, having an oolitic structure, that give intelligence of the origin of the beds in which they are contained. I have stated that in the lower group of Carboniferous rocks there are beds of chert that are in structure oolitic. It is the ruins of these that have furnished the oolitic pebbles. Hornstone and agate also occur in these beds, and are doubtless the origin of the pebbles of these minerals. The degradation of the conglomerate of the millstone grit of the valley, has also contributed quartz and other siliceous materials. But we are not left altogether to infer from identity of mineral composition that the loose materials that cover the surface around Tuscaloosa have traveled from north to south from 100 to 150 miles, for we can trace the very path they traveled by the monuments they have left behind them on their journey. Along Jones' Valley beds of pebbles may be traced in spots beyond the influence of any cause now in operation that could place them there. And almost in the streets of Elyton, Dr. Earle directed my attention to a low and narrow ridge composed of these materials; add to this, that I have found at Tuscaloosa in these beds, fossil corals, and among them a species of *strombodes*, a Carboniferous fossil, and I think there can be but little risk in stating that the materials of these

beds have traveled at least from the lower edge of Blount County, a distance of 70 miles. Within a very few years they have again taken up their line of march, and are fast hastening on their downward course from Tuscaloosa. Tons are transported to the river by every shower of rain, and the only wonder is that the navigation of the Warrior has not long ago been impeded by this vast accumulation that is taking place in its bed. * * * I am obliged to conclude that the beds around Tuscaloosa are newer than the Eocene Tertiary of the State.

Again, in his second report, p. 144, 1858, he says:

"They are found on the highest elevations, and are strewed along the valleys. Across the middle of the State and north of the verge of the Cretaceous rocks they are found in greatest force. Tuscaloosa stands upon these beds, as do the cities of Columbia, S. C., Petersburg and Richmond, Va. Washington and Baltimore have also their foundations on these strata.

"The deposits everywhere show the action of water; they are often obliquely laminated, and sometimes beds of clay occur between the strata of sand and pebbles, indicating a short period of repose in the agitated waters. North of the paper mill at Tuscaloosa a bed of swamp-mud four feet thick outcrops at the base of a bank in a ravine covered by a stratum, 20 or 30 feet in thickness, of the usual materials of these beds. The remains of grass, charred wood, compressed stems of woody plants, and the elytra of insects are found abundantly. I have elsewhere mentioned that they are among the newest beds of the State, excepting the alluvial now in process of formation, but I hesitated about referring them to any particular period. I now think that they belong to the *drift*, although having but few points of resemblance to that formation at the north, *There* considerable deposits are thrown together, containing large angular and rounded masses of rock that could scarcely have resulted from the action of water alone; *here* the largest of the rounded fragments seldom, if ever, exceed six inches in diameter, and there are no angular masses, excepting in the instances that I have mentioned, and the action of water in motion is everywhere impressed upon one as the sole transporting force. A remarkable feature in the distribution of this formation is its appearing in greatest force parallel with the Tertiary plane of the United States, and crossing the rivers at their falls. These beds are indeed scattered farther south, but their greatest accumulation takes place here, the thickness being often 100 feet.

"If the southern drift be at all connected with that of the north, it may be explained by supposing that the northern glaciers suddenly melted, and that the water thus liberated in immense volume took a southern direction, carrying with it the *débris* torn from the surface over which it passed, until it met the Tertiary sea, upon the shores of which its burden was deposited. It is difficult to suppose that any force acting upon hard siliceous fragments for so short a time as that necessary for their transportation from north to south would so completely round and polish them, and if we suppose these materials to have been already water worn and scattered over the surface, and that they were merely brought together by the force, still one would suppose that a very considerable quantity of angular fragments would also be torn up and transported with the rest, which is not the case. But after all, we know too little of the grinding force that may be exerted by a mass of loose materials 100 feet in thickness when in motion. This theory would sufficiently well account for that enormously long ridge of drift extending parallel with the Atlantic coast, for the moment the current entered the Tertiary sea its velocity would be checked and the greater part of the transported *detritus* deposited.

"It can be demonstrated that this accumulation took place at a time when, if our southern rivers existed at all, they did not occupy their present beds, for they have almost all cut through the drift after its deposition. In supposing that the drift was deposited on the margin of the Tertiary sea, the difficulty meets us that in the southern drift we have no marine remains, nor, in truth, organic remains of any sort, beyond the silicified wood already mentioned; and yet beds of clay and fine sand are deposited in a manner that indicated a period of repose, and conditions favorable to the preservation of organic remains, if any organism existed in the sea. The only way by which I can account for this absence of every vestige of life in a sea that once teemed with life, is by supposing that, before the drift period, the bottom of this sea had been elevated and converted into dry land, and that at the commencement of the drift period a depression of the land took place; that the time between the influx of the sea and the deposition of the drift was too short for marine animals even to have commenced a colonization, and that the land was again elevated into its present position, and subjected to long continued denudation, which produced its present configuration; that after this elevation the rivers excavated their present channels. It must obviously be very difficult to assign the limits of the southern drift, for it is found scattered over the States, the materials becoming smaller as we proceed south, till they mingle with the sands on the coast, from which they cannot be distinguished. The remains of the mastodon are found on the surface or are washed out by the streams."

BLUFF OR LOESS.

Prof. G. C. Swallow in Geological Survey of Missouri, p. 69, says:

"The geological position of this formation in the series of Missouri rocks is easily determined. That it is newer than the drift is satisfactorily proved by the fact that it rests upon the latter formation, when both are present and undisturbed. It caps nearly all the bluffs of the Missouri and Mississippi within our State, forming the very highest deposits skirting their valleys. Thus while the bottom prairie occupies a higher geological horizon, the bluff is usually several hundred feet above it in the topographical.

"This formation, when well developed, usually presents a fine, pulverulent, obsoletely stratified mass of light grayish buff, siliceous, and slightly indurated marl. Its color is usually variegated with deeper brown stains of oxide of iron. The bluff formation is often penetrated by numerous tubes or cylinders, about the size or thickness of pipe-stems, some larger and others smaller. They are composed of clay, carbonate of lime, and oxide of iron, being argillo-calcareous oxide of iron or calcareous clay ironstone."

These he attributes to the decayed roots of oak trees and other plants, and states further that—

"These phenomena have been thus minutely investigated, not merely as interesting scientific facts, but, also, as one of the most useful agricultural features of this pre-eminently valuable formation; for, upon it, and sustained by its absolutely inexhaustible fertilizing resources, rest the very best farms of the Mississippi and Missouri valleys."

These tubes and holes, also, constitute the most thorough system of drainage imaginable.

A specimen of this deposit, collected at Hannibal, Mo., gave Dr. Litton, in one hundred parts, dried at 212° F.—

Silica	77.02
Alumina and peroxide of iron	12.10
Lime	3.25
Magnesia	1.63
Carbonic acid	2.83
Water	2.43
	99.26

According to Bischoff's Chemical Geology, the loess of the Rhine, supposed by some to be identical with our own bluff, gives the following result from two analyses:

	I.	II.	III.
Silicic acid	58.97	81.04	62.43
Alumina	9.97	9.75	7.51
Peroxide of iron	4.25	6.67	5.14
Lime	0.02	.....	.....
Magnesia	0.04	0.27	0.21
Potash	1.11	2.27	1.75
Soda	0.84		
Carbonate of lime	20.16	.....	17.63
Carbonate of magnesia	4.21	.....	3.02
Loss by ignition	1.37	.....	2.31
	99.94	100.00	100.00

These analyses show a striking coincidence in the composition of these widely separated formations.

David Dale Owen, in Arkansas Geological Report of 1860, p. 412, in the description of Phillips County, says:

"Crowley's Ridge, which runs through Greene, Craighead, Poinsett, and Saint Francis Counties, forming the divide between the waters of the Saint Francis and White Rivers, terminates in Phillips County, just below the city of Helena. The top of this ridge throughout its entire extent in Arkansas is composed, for the most part, of siliceous clays and marl of Quaternary date, usually resting on a bed of water-worn gravel."

The counterpart of Crowley's Ridge may be seen on the opposite side of the Mississippi River, at Memphis; thence running northward through the State of Tennessee and a part of Kentucky, crossing the Ohio River at Caledonia, in Illinois. In Tennessee this ridge reaches the river at the first, second, third, and fourth Chickasaw bluffs. In Kentucky at Hickman, Columbus, and Jefferson's Bluff. The fourth

Chickasaw bluff, on which Memphis is built, has an elevation of some 70 feet above low water, and is entirely composed of yellowish marly clay, belonging to the Quaternary. At Randolph, on the second Chickasaw bluff, the elevation is 200 feet above low water, and, for the sake of comparison, the following section obtained at that place is here given:

		Feet.
Quaternary	Sandy soil and subsoil Yellowish marly clay	85
Tertiary	Purplish pink clay	0½
	Yellowish sand and gravel	10
	Brown siliceous and lignitic clay shale	20
	Upper bed of lignite	2
	Ash-colored clay with fossil leaves	11
	Lower bed of lignite	2½
	Space—ash-colored siliceous clay (?) to low water Mississippi River	70
	Aggregate	201

The yellow sand and gravel bed at the junction of the Quatenary and Tertiary is very variable in its character, but marks a distinct horizontal through a district of country many miles in width, and, so far as known, extends in length from the southern part of Arkansas, running with a northeasterly strike through the eastern part of that State, the western part of Mississippi, Tennessee, Kentucky, and terminating in the southern part of Illinois. It is this member, cemented into a hard ferruginous conglomerate, which crosses the Ohio River at New Caledonia, in Illinois, and forms the Grand and Little Chain on that stream.

Prof. B. L. C. Wailes, in his Report on the Geology of Mississippi, in 1854, p. 213, describes the

LOESS OR LOAM.

"A prominent and interesting feature which distinguishes the counties bordering upon the Mississippi below the Yazoo is found in that considerable deposit superimposed on the diluvial gravel, and which enters into the more easternly range of counties only along the margins of the Homochitto, Big Black, and Yazoo Rivers. Its average width on the east side of the Mississippi does not exceed 12 miles, and it is not met with at all on the western side, at least below the high lands of Arkansas. In the escarpment of the Mississippi bluffs, and in other natural sections, it is seen frequently of the thickness of 50 or 60 feet, thinning out as you recede from the river, until it is lost, and the red sands and pebbles on which it rests appear upon the surface. European geologists describe it, under the name of Loess or Luhm, as 'an alluvial, tertiary, sedimentary deposit, consisting of very fine, well washed, yellow, calcareous loam, occurring over considerable tracts and found reposing on every rock from the granite of Heidelberg to the gravel on the plains of the Rhine.' Here it has not the character of a local alluvium, and is probably due to the same causes that have spread the gravel and pebble deposits so widely over the surface."

"In March, 1846, being desirous of drawing the attention of Mr. Lyell, then on a visit to this State (Mississippi), to this peculiar and interesting deposit, he accompanied me on an excursion to one of the large ravines in Adams County, where it is exposed to the depth of at least 50 feet. Speaking of the result of this examination, in his travels subsequently published, he remarks that the 'resemblance between this loam and the fluviatile silt of the valley of the Rhine, generally called loess, is most perfect. Its imbedded fossils are chiefly bleached helices or snail shells, together with mammalian remains. At every bluff on the Mississippi, from Fort Adams to the Yazoo, and on the hills in the rear, this loam is seen, and the roads leading into the interior cut into it deeply, and expose it on every hand'"

Again, on page 283, he remarks: "In the lake marl, which occupies the lacustrine beds of the drift period, we find a few fossil *testacea*, such as *lymnea*, *succinea*, *cyclas*, two species of *planorbis*, and a very small *paludina*. One species of the *planorbis*, a very minute one, and the *paludina* mentioned, are not now found living in our waters; the others belong to existing species. The *testacea* of the loess, or loam, referred to the same period, are, on the contrary, all terrestrial, embracing several species of helices or snails, all of which, it is believed, are yet found living in different parts of the continent, although some of them seem to have disappeared, or to have now no living representative in the fauna of this region. Among the species most numerous may be enumerated the *helix albolabris*, *alternata*, *cancara*, *elevata*, *fraterna*, *perspectiva*, *profunda*, *thyroides*, *tridentata*, &c. The great bone bed of the Mississippi, or the depository of the extinct mammalia, is also found in the loess, the limits of which have already been defined. Throughout its extent the remains of the mastodon have been discovered.

Mastodon bones have been obtained in Bayou Sara, near Pinckneyville, in Wilkinson County, in various localities in Adams County, in Jefferson County, near the former town of Greenville, and in Warren County, in the deep cut of the railroad at Vicksburg, and in the vicinity of Big Black River, near the eastern line of the county. In a few localities, such as the accompanying *testacea* would indicate to have been the beds of fresh-water ponds or marshes, considerable portions of the skeleton have been found together, as if the animal may have perished there, and in such cases the bones are frequently in contact with considerable masses of a black, fatty earth, entirely dissimilar from the surrounding marl, and which may reasonably be supposed to have resulted from the decomposition of the viscera and the other perishable animal matter; but most usually the bones appear detached, as if drifted into their present position, and consequently it is not unusual to find a tusk, or a molar, a bone of the leg, or a joint of the vertebra where no other vestiges are seen.

The most prolific locality of these remains is in Adams County, on Pine Ridge, in townships 7 and 8, range 3 west, about six miles north of Natchez, where a large and deep ravine has extended i s ramifications over an area of several miles, and which, in its undermining progress of denudation, has been constantly exposing these remains for more than forty years, or from a period coeval with the first cultivation of the country through which it has its course. The bones generally lie from 10 to 20 feet below the general surface, and in the ravine on Pine Ridge the remains of other animals have been found with them.

Among these may be enumerated those of the megalonyx and the tapir. Besides these the teeth of the fossil horse and ox are frequently found. Those of the *Bos* are referred by Dr. Leidy to the *Bison Latifrons* (5th vol. Smithsonian Contrib.). I am indebted to Dr. Leidy for the following list of mammalia:

Felis atrox.
Ursus Americanus (*fossilis*).
Ursus amplidens.
Equus Americanus.
Cervus Virginianus.
Bootherium cavifrons.
Elephas primigenius.
Tapirus Americanus and *fossilis.*
Megalonyx Jeffersonii.
Megalonyx dissimilis.
Mylodon Harlanii.
Ereptedon priscus.
Mastoāon giganteus.

In the report of Captain Marcy of Exploration of the Red River in 1852, Appendix D, page 183 the statement is made that "Dr. Shumard found on the Red River, 26 miles from Fort Washita, a deposit of ash-colored loam, 25 feet thick, containing terrestrial and fluviatile shells of the genera *lymnea*, *physa*, *planorbis*, *pupa*, and *helix*, the whole resembling species found in the loam at New Harmony, Ind, and elsewhere in the Mississippi Valley. This formation along the Mississippi constitutes what are known as the "Bluffs," and is a fluviatile accumulation laid down by the river when the region was at a lower level. In other words it is an ancient alluvion. Its thickness and known extent along the Mississippi render it very probable that it will be found along most of the principal tributaries of that river. A similar deposit is found along the valley of the Rhine. Its thickness is from 200 to 300 feet, and it is a yellowish grey loam, consisting chiefly of clay, combined with sand and carbonate of lime. The same deposit is found along most of the principal valleys or tributaries of the Rhine; it evidently having been contemporaneously deposited. It is known in Germany under the name of loess. The occurrence of a formation along the Red River, similar to those described, leads me to believe that it will be found along most of the rivers which are tributary to the Mississippi, and it is quite probable that in the environs of Preston, and even over broad tracts of that region, there are extensive superficial alluvial deposits, which afford a soil that can scarcely be surpassed for its richness and fertility."

Extracted from Reports of Explorations and Surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War in 1853–'54, volume II, Thirty-third Congress, third session, Ex. Doc. No. 91, Prof. J. M Stafford describes the condition of things in Tennessee as follows, page 113, Report on Tennessee, 1869—

THE MISSISSIPPI BOTTOM OR BOTTOMS.

Much of the area is covered with swamps and lakes; much, too, is wild and dark, with heavy forests, even yet the retreat of the deer and other wild animals. Other portions, confined for the most part to a belt bordering the river, are in a good state of cultivation. The undeveloped agricultural resources of the division (of the State) as a whole are great, and, in proportion to its area, may make it some day, when its lands shall have been reclaimed, the wealthiest part of the State.

This magnificent valley plain (or bottom valley) is altogether, including the delta of the river, which is but the extension of the plain into the Gulf of Mexico, about 600 miles long. Mr. G. W. R. Bayley, a civil engineer of Louisiana, thus defines its

limits: "The head of alluvial plain or delta of the Mississippi may be assumed as occurring where rock *in situ* forms both shores, or at a point some 30 miles above the mouth of the Ohio, known as 'the Chains.' The entire alluvion, extending thence to the sea, comprises an area of about 40,000 square miles, and presents a front upon the Gulf of Mexico of 260 miles, 85 miles north and 175 miles west of the river's mouth."

Sir Charles Lyell says of the valley plain, "It is very variable in width from east to west, being, near its northern extremity, or at the mouth of the Ohio, 50 miles wide; at Memphis, 30; at the mouth of White River, 80, and contracting again farther south, as at Grand Gulf, to 33 miles."

Taking high-water level as that of the great plain, the latter attains, at the mouth of the Ohio, an elevation of 320 feet above the Gulf. Considering the distance, the slope seaward is, therefore, very gradual. The valley plain proper is bounded on the east and west respectively by two ranges of highlands, approximately parallel, and rising from 50 to 200 feet above the plain. These highlands generally present steep slopes or faces toward the plain, but preserve, for the most part, their elevation in the opposite direction, extending off as table-lands. The Mississippi has probably during past ages occupied successively all parts of the area. At one day it may have washed the base of Crowley's Ridge. The valley plain, as a whole, is of great antiquity. It has, apparently, however, been washed out of another more ancient and extensive alluvial plain, the remains of which are seen at a higher elevation, in the slopes and cliffs of the highlands on each side (as, for example, in the bluffs of Tennessee, and in the slopes of Crowley's Ridge, in Arkansas). These highlands have a corresponding elevation. They present, too, along their opposite faces, the same vertical succession of formations. The strata of loam, gravel, sand, and clay, whose edges now crop out upon their slopes, once extended across from side to side in continuous layers, forming the more ancient and higher plain. It has been the work of the river to carve out of this greater plain its great valley of "bottoms." The eastern bluff and the western ridge are, at this day, the limits of its lateral movements, and remain, moreover, as monuments of the great changes that have occurred.

It is the opinion of Sir Charles Lyell that an extensive region, including the valley plain of the Mississippi, has been subjected to a great oscillation of level. This at first depressed the region, or rather the more inland portion of it, about 100 feet below its present level and then restored it again to its former position. During the first part of this oscillation, and at the period of greatest depression, the materials of strata, the remnants of which are now seen in the bluffs and slopes of the highlands, were deposited during overflows, very much as alluvial matter is now. But when the movement was reversed and the region was slowly upraised, the river carved out its valley "through the horizontal and unconsolidated strata as they rose, sweeping away the greater portion of them, and leaving mere fragments, in the shape of terraces, skirting" the newly formed alluvial plain "as monuments" of the changes in level.

THE BLUFF LOAM.

(Safford, p. 433.)

This, the topmost of the bluff formations, is generally a mass of silicious loam, somewhat calcareous, and usually of a light ashen yellow or buff color, but sometimes lacking the yellow tinge. It is distinctly stratified, contains land and freshwater shells, and frequently oddly-shaped calcareous concretions. It has in Tennessee a maximum thickness of about 100 feet, ranging generally, however, from 30 to 80 feet. In the bluff at Memphis, it is from 40 to 60 feet thick, and presents in its lower parts, along a well-marked horizon and in a vertical position, earthy ferruginous casts or molds of what may have been the long tapering roots of some tree.

The loam rests directly upon the bluff gravel. The following species of shells have been collected from this formation:

1. *Helix appressa*, Memphis.
2. *Helix hirsuta*, Memphis.
3. *Helix monodon*, Memphis.
4. *Helix solitaria*, Dyer County.
5. *Helix profunda*, Hickman, Ky.
6. *Planorbis bicarinata*, Memphis.
7. *Cyclos sp.?* Memphis.
8. *Amnicola lapidaria*, Memphis.
9. *Lymnea sp.?*
10. *Succinea sp.?*

Dr. Wyman has published a "Notice of Fossil Bones from the neighborhood of Memphis," which he states are representatives of the genera mastodon, megalonyx, *castor* and *castoroides*, and that they are "from, as is supposed, the diluvium of the Mississippi." The geological position, as given here, is very indefinite. I think it, however, more than probable that the bones came from the bluff loam.

THE BLUFF GRAVEL.

(p. 432.)

This bed varies in thickness from 10 to 50 feet. It consists generally of coarse yellow and orange sands, with everywhere more or less coarse gravel, and has usu-

ally a layer of white or variegated clay at its base. The gravel is generally the most conspicuous portion. This is sometimes cemented by oxide of iron (occasionally by calcareous matter) into great blocks of coarse conglomerate. It consists of water-worn pebbles from the size of a man's fist down to that of a pigeon's egg. The pebbles have been derived mostly from carboniferous chert. The bluff gravel is remarkable for its extent in a general direction parallel with the river. It is seen along the face of the Mississippi bluff from the Mississippi line to Kentucky, and both ways much beyond these limits.

Its eastern outcrop is not well marked. It appears to extend from 15 to 20 miles eastward from a straight line drawn through the most westerly parts of the bluff.

At Memphis, the highest part of the bluff is about 100 feet above low water. The part of the section at this point belongs to the bluff gravel, and consists of alternating layers of yellow, orange, and white sands, containing towards its base more or less gravel. It also contains a few seams of whitish clay. At some points, also, masses of ferruginous conglomerate occur, as well as thin plates and scrolls of red sandstone. In a branch back from the river a bed of coarse gravel was observed.

I have given the foregoing full statements of the principal observers of the Quaternary formations to show, in the first place, the identity of the southern drift in point of time with the northern drift, which, north of the Ohio, has had such an important agency in modifying the surface of the States bordering on the Upper Mississippi. Secondly, to show that the glacial forces were sufficient to erode the original wide bed of the Mississippi, forty miles wide between Memphis, Tenn., and Madison, Ark.

The facts given also show that this bed has been refilled by the loess which immediately overlies the drift as far south as Memphis.

We come now to consider the features of the Port Hudson hard-pans and clays:

My attention was first called to a blue clay in Coles County, Mississippi, in 1860, underlying the loess and overlying the drift.

In Hilgard's Report on the Geology of Mississippi, printed in 1860, but published in 1866, I found a description of a blue clay on the Chickasawkay River, near Winchester, referred by him to the Tertiary, which contained roots and trunks of *cupuliferæ*, *coniferæ*, and *palmæ*.

On examination of this stratum and making further explorations in Southwest Mississippi, in which the same clay was found on Buffalo Creek and other creeks in that region, containing bones and teeth of the mastodon, and on comparing these deposits again with the exposure at Port Hudson and its clays, I came to the conclusion that they were all of the same age, and formed a group which was intermediate between the bluff and drift, and that there had been a more or less continuous stratum over the whole Mississippi bottom, and in the valleys of some of the rivers, which had been removed in parts of the bottom by the action of the river.

Dr. E. A. Smith, at that time my assistant in the Mississippi survey, was directed to examine the Yazoo bottom, and his observations showed that in digging wells, after passing through the alluvium, a blue clay stratum, as much as 40 feet in thickness in places, was uniformly penetrated before reaching water which was found in the underlying sands and pebbles of the drift. The observations made during the last year confirm the opinion that this stratum has been continuous from Memphis to New Orleans, but has, in many portions of the bottom, been removed by the river, and its place supplied by the newer alluvial deposits, which now, as a general thing, form the banks of the river, and are being constantly removed, so that the levees, which have been built at enormous expense, require constant care for their preservation or frequent renewal.

PORT HUDSON.

In a paper read before the American Association for the Advancement of Science, at Indianapolis, in 1872, and published in the proceedings for that year, Dr. E. W. Hilgard speaks thus of the Port Hudson group as laid down on the accompanying map:

"The next formation laid down on the map is the Port Hudson group, of which, however, the outcropping littoral portion only is here represented. Properly speaking, it should be shown as occupying also most of the space colored as alluvial, since it underlies not only the marine alluvium (and a portion of the Gulf itself) but also that of the Mississippi and its chief tributaries, at least as high up as Memphis, and on Red River, nearly, if not quite, up to Shreveport. It seems to exist equally in the valleys of other larger rivers tributary to the Gulf; notably in that of the Pascagoula, up to 100 miles (in a direct line) from the coast."

"Having discussed this formation somewhat in detail in papers recently published, I will merely state that it embraces a group of partly littoral and estuarian, partly swamp, lagoon, and fluviatile deposits whose thickness and location are manifestly dependent upon the topographical features of the continent, then (during the "Champlain" period in progress of slow depression, as shown by the nature of the deposits and the numerous superimposed generations of large cypress stumps imbedded in

laminated clays exhibiting the yearly fall of leaves. These beds overlie those of the orange sand, or stratified drift, which (*sic*) they themselves are overlaid by, not only the river alluvium, but also by the loess or bluff silt or its equivalents, as well as where this is absent by the yellow loam of the surface. It would seem that here also, during the latter portion of the Drift period, most of the larger river channels were already impressed upon the surface, though not always coincident with the present immediate valley, as Newberry has observed in relation to some of the northern rivers. A depression of the land would gradually transform these channels into inlets filled with more or less stagnant fresh water down to a greater or less distance from the then existing coast line, and thus opportunity would be afforded for the formation of the swamp and lagoon deposits into which both the Mississippi and Red Rivers have subsequently cut their channels. The banks of the Red River, as well as outside the present alluvial area, those of the many lakes and bayous which border that stream, exhibit strata absolutely identical in character with those observed near the coast, yet of course totally different from either the alluvial deposits of the present time or the adjoining tertiaries. The same holds true, more or less, of the Mississippi and its "mighty bayous." According to the observations of Dr. E. A. Smith in the Yazoo bottom, and my own in that of the Tensas, not only do the clays with calcareous concretions (as characteristic of the Port Hudson age, as they are foreign to the alluvium of to-day) frequently crop out in the beds of the streams; but much of the best lands of the "buckshot" kind, now situated above overflow, have clearly been formed by simple disintegration of these strata, altogether independently of the river alluvium."

"These results fully confirm, therefore, the statement made by General Humphreys, that the Mississippi does not, as a rule, flow in a bed formed from its own deposits, but has excavated it in an older geological formation. Wells exceeding 15 or 20 feet ordinarily strike these clays throughout the bottom as they do in the delta; and the analogy has been completed by the repetition of the phenomena observed in driven wells at New Orleans and at a point about fifty miles above Vicksburg (General Wade Hampton's plantation), where a tube well has furnished a copious flow of combustible gas undiminished for many months. The swamp clays form, however, only the lower portion of the Port Hudson beds. Higher up, as shown at the Port Hudson bluff, there lie yellow or whitish silts and 'hard-pans.' These form also a level terrace some miles in width, bordering the Tensas bottom; while high above it, on the hill tops of Sicily Islands, on the Washita, lie the remnants of the Loess formation, the main body of which has succumbed to the erosive influence of the Terrace epoch of elevation. It has, however, left a belt a few miles wide on the eastern side of the valley, as shown on the map. It would thus seem that during the latter portion of the period of depression the rate of sinking became at times too rapid to allow the accumulation of swamp deposit. The indurate silts are mostly devoid of fossils of any kind, but are occasionally traversed by fluviatile beds with pebbles, drift-wood, &c. Then there is a recurrence of the swamp deposits; then again silts; and finally the calcareous, silty loam of the bluff formation, with its numerous terrestrial fossils and "loess puppets," ends the deposits clearly referable to the epoch of depression."

"The loess differs little from its equivalent farther north, save in being utterly devoid of stratification, as well as of any fluviatile organisms. It is not easy to imagine the *modus operandi* by which a deposit of this kind, sometimes 70 feet thick, and of dead uniformity from top to bottom, could be produced. Its equivalents farther north exhibit very distinctly the structure resulting when deposition takes place in (gently) flowing water; at the south it was probably substantially stagnant, save as regards the tidal flow. Perhaps the latter may serve to explain both the absence of fluviatile as well as marine life, and the uniform intermixture, without any semblance of arrangement of material, varying from the finest silt to pebbles half an inch in diameter. A strong tidal wave running up a deep inlet of this kind would naturally sweep away in its periodical rushes many members of the terrestrial fauna, whose remains are in a marked degree the more abundant the nearer we approach to the edge of the formation. Overlying the loess we find, whenever opportunity is afforded, a stratum of yellow loam or brick clay, which near the larger valleys is often as much as 15 or 20 feet in thickness. It is altogether devoid of stratified structure, as well as of fossils, and forms the surface layer and in most cases the subsoil of the Gulf States. If, as I am inclined to believe, its presence as a connected though very undulating sheet, on all but the most elevated uplands of these States, necessitates the assumption of submergence, however brief, to the highest level at which it occurs, the changes of level heretofore alluded to would be shown to have exceeded by 600 to 700 feet the estimate given above."

"The succeeding (Terrace) epoch of elevation has not, so far as I am aware, left any marks in the way of beach lines or terraces, unless the second bottoms or "hommocks" be accounted such. They, however, belong to a very modern epoch, for they occur on streams no larger than what is usually called a 'creek,' and are most marked on

the smaller rivers, while apparently absent from those of the largest size, such as the Mississippi, Red, and Arkansas rivers. The elevation at which on the very Gulf shore we find deposits of the Port Hudson age (180 feet at the Five Islands, on Vermilion Bay), shows, nevertheless, that a stupendous amount of erosion was accomplished during the time that the Mississippi occupied in scooping out its channel to a depth which, even below the northern boundary of Louisiana, cannot be estimated at less than 500 feet. As regards the modern epoch, I will remark that, while in the axis of the ancient embayment the Mississippi River, through the singular instrumentality of mud-lumps upheaval, is rapidly pushing out the land into the Gulf waters, the latter are nevertheless gaining ground on almost the entire coast of Mississippi and Alabama, and the same is true of a portion of Vermilion Bay. Yet, on the whole, the coast of Louisiana, as well as that of Texas and Florida, is more than holding its own, and the shallowness of the water, even where encroachment does take place, will necessarily restrict the latter within narrow limits hereafter."

At the same meeting of the association Dr. E. A. Smith, assistant in the Mississippi Geological Survey, read the following paper:

"It has generally been assumed that the formation underlying the Mississippi bottom was exclusively of alluvial character. (See Lyell's Principles of Geology, tenth edition, ch. XIX, vol. 1.) On the other hand, it has been suggested by General Humphreys (Report on the Mississippi River, p. 99), 'that the river is flowing through it (the delta region) in a channel belonging to a geological epoch antecedent to the present.' On page 84, 'From McNutt, in latitude 33° 40′, to Sunflower River, in latitude 34° 22′, underlying the vegetable mold and alluvion, is a stratum of dark, heavy clay, which, where exposed, is called 'buckshot' land by the settlers, from its fancied resemblance to leaden balls when it has been baked and cracked by the sun.'"

"Dr. Hilgard remarks (American Journal of Science, January, 1869), "The stump stratum No. 1 (Port Hudson profile), however, as appears from numerous data collected by myself or contained in Humphreys' and Abbot's Report, exists at about the same level (*i. e.*, near that of tidal water), not only over all the so-called delta plain of the Mississippi, but also higher up, perhaps as far as Memphis."

"Observations made by myself in the Yazoo bottom during the last year led to the conclusion that the true river deposits of any considerable thickness are mostly confined to narrow strips of land lying on each side of the Mississippi, and of the bayous and creeks that form a network of streams throughout the bottom, and to ancient channels since filled up, while a large proportion of the superficial area of the bottom, including some of the most fertile lands, is derived from the clays of older formations into which the beds of these streams have been excavated.

"The high or front land on the immediate banks of the streams is at present rarely overflowed. It is usually a sandy loam of various degrees of fertility. It supports a growth of sweet-gum, honey-locust, swamp-chestnut, oak, water-oak, pecan, and cane. The growth varies with the locality and character of the loam, as may be seen better hereafter in the remarks preceding the analyses. These highlands seem to represent the true river alluvium. From the "front land" there is a gradual slope down toward the swamp. The soil undergoes a transition from the sandy loam into the tenaceous clays of the middle or 'back land.' The latter is often overflowed during the wet seasons, and it supports a growth of sweet-gum, over-cup oak, willow, and water-oak, hackberry, pecan, and cane.

"The clays of the 'back land' doubtless belong, for the greater part, to the Port Hudson age, as is indicated by the abundance of ferruginous and calcareous concretions found in them, unlike any found in the true river alluvium, as well as by the great thickness of continuous clay deposits.

"These clays are generally of a dark gray color, sometimes nearly black; again, light gray, traversed by cracks and full of streaks and dots of ferruginous matter. They are very sticky and tenacious, and when exposed in large masses to the atmosphere become covered on the surface with a dull red coating of hydrated ferric oxide. When broken up by the plow or spade they crumble on drying into small angular blocks of the size of a buckshot and under, giving rise to what is known throughout the bottom as buckshot soil. Although these clays, as shown by analysis, are generally very rich in lime, yet calcareous concretions, so characteristic of the Port Hudson strata, are not always to be found in them. Thus, I have not observed them farther south than the latitude, 32° 52′, of Yazoo City. North of that point, however, they are of constant occurrence.

"The uniformity of level in the bottom may very well account for the failure to observe these concretions, for anything like a fair profile is very rarely seen. The banks of the creeks and bayous are usually of such a gentle slope and so covered with detritus in their lower parts that little of interest can be observed without much digging. As we go from the 'back land' to the cypress swamp there is frequently very little change in the nature of the clay; and it is difficult, if not impossible, to distinguish between the 'buckshot' clay of the older formation and that of the recent swamp, except where the calcareous concretions above mentioned come to

our aid. The clays of both formations are usually dark gray, traversed with cracks, and full of ferruginous matter; both crumble into "buckshot;" both support a similar vegetation, except where the presence of more or less standing water affects it. As the swamp is under water for a large part of each year there is one alternation in its deposits between clay, leaves, and sand. One of the most characteristic sections of Port Hudson strata observed is on the bank of Tchula Lake, at the head of Honey Island. The three uppermost strata represent the alluvium, while those below are of the true Port Hudson character. (See section.) On the banks of the Yazoo River, not far from where the above section was taken, the succession of the strata was essentially the same; but the buckshot clays corresponding with Nos. 4 and 6, *supra*, were entirely full of calcareous concretions, while the ferruginous concretions occurred at a lower level, nearly down to the water's edge, as is the case of Port Hudson.

"On Lake Beulah, in latitude 33° 40′, in Bolivar County, the same strata appear; the clays, Nos. 4 and 6, being full of calcareous concretions. On Panther Creek, above Yazoo City, and on a small bayou which empties into the river at the city, the same facts may be observed.

"Of the stump stratum, No. 1, of Dr. Hilgard's profile, I have not seen any outcrop on the banks of bayous, &c., on account of the difficulties mentioned above. Logs, however, have frequently been struck in digging wells; though the introduction of tube or driven wells has very much impaired this source of information regarding the strata in the bottom.

"For instance, on General Wade Hampton's Walnut Grove plantation, near Lake Washington, in latitude 33° 05′, at a depth of about 30 feet in the blue clay which underlies the dark gray 'buck-shot' clay a fragment of wood was found. On the same plantation, while driving a tube for the purpose of obtaining water, a stream of inflammable gas was observed to issue from the tube. At the time of my visit there the gas had been burning uninterruptedly for three months. It escapes with considerable force, and might easily be utilized on the plantation.

The composition of this gas is as follows:

$C H_4$	= 74.30
N	= 19.00
H	= 3.20
$C O_2$	= 3.50
	100.00

"The small percentage of carbonic acid found in the gas shows that it does not originate from vegetable matter in its first stages of decomposition, agreeing in this respect with the gas obtained from similar wells in New Orleans, and differing from the gas of recent marshes which contains from 8 to 10 per cent. Below the stratum of blue clay, in which sticks, logs, &c., are found, there is a stratum of pebbles and sand, of the orange sand (stratified drift) formation. This pebble bed is very often reached in digging wells. The depth varies very greatly; thus at the mouth of a small bayou which empties into Lake Washington on the west side there is a bed of pebbles, as is also the case at Proffit's Island near Port Hudson, while in some wells it is not reached at a depth of 120 feet.

WATER.

"Throughout the 'bottom,' water is obtained either from shallow dug wells, 15 to 30 feet deep, or by means of iron tubes driven into the ground, as deep sometimes as 100 feet or more. The water always rises in the tubes to within 30 feet of the surface of the ground; in most cases to a level higher than that of the river and streams in the neighborhood; and in one instance known to me, of a well on Indian Bayou, the water stood permanently in the tube 2 feet above the surface. Generally the water is of a decidedly mineral character, especially in the very deep wells. When the tubes have been driven no deeper than 25 or 30 feet, the water is frequently as free from a mineral taste as the river water, though always hard. I have made numerous analyses of the water from the driven wells, from various localities, from Lower Deer Creek, in latitude 32° 40′, to the latitude 34° 23′ of Friar's Point, in Coahoma County, and the composition appears to be nearly the same in all. The following is an analysis of the water from Governor Alcorn's place near Jamestown, Coahoma County. The well is 119 feet deep. The water when first drawn is clear and sparkling; but soon becomes turbid, and deposits a ferruginous film upon all the vessels in which it stands for any length of time:

$Fe O C O_2$	dissolved in free Carbonic acid	4.877
$Ca O C O_2$		19.575
$Mg O C O_2$		17.672
$Si O_2$		17.482
$Ca O S O_3$		0.610

Na Cl	1.746
Na O, H O } $2CO_2$	12.852
K O, H O } $2CO_2$	9.969
Ca O united with organic acid	14.665
Mg O united with organic acid	0.560
	100.008

SOILS.

"The soils of the Yazoo bottom may be arranged in five classes, which differ materially from each other in fertility as well as in general physical properties; the differences in their chemical composition are very striking, as may be seen by reference to the table.

"First. A light-colored sandy clay, of close texture, with a few yellow spots. The growth upon this soil is swamp-chesnut-oak chiefly; with sweetgum, ash, maple, willow, oak, and an undergrowth of cane. This soil forms the white lands, which are considered very fertile. It occurs on Silver Creek, east of Sunflower River, and on Indian Bayou, west of the same; and is common in the vicinity of the Sunflower on both sides, and forms most of the cultivated lands on the banks of the bayous that have their courses at right angles to the Sunflower.

I.—*Indian Bayou front-land soil, Sunflower County.*

Insoluble matter	87.898
Silica, soluble in Na O, C O_2	4.036
Potash	.226
Soda	.116
Lime	.153
Magnesia	.256
Brown oxide of manganese	.048
Peroxide of iron	1.848
Alumina	2.565
Phosphoric acid	.162
Sulphuric acid	.042
Volatile matter	3.013
Total	100.363

"Second. A dark-gray sandy loam, forming the front-land of many of the creeks and bayous. It is fertile and easily cultivated. The growth is honey-locust, hackberry, and sweetgum; and, where entirely above overflow, dogwood is a very common tree. I may add, however, that the dogwood ridges are inferior in fertility to others where the soil is a similar dark-gray sandy loam.

II.—*Dogwood Ridge soil, J. L. Alcorn's plantation, Coahoma County.*

Insoluble matter	83.886
Silica soluble in Na O C O_2	7.022
Potash	.392
Soda	.086
Lime	.259
Magnesia	.596
Manganese, brown oxide	.086
Iron peroxide	2.691
Alumina	3.593
Phosphoric acid	.142
Sulphuric acid	.010
Volatile matter	2.007
Total	100.770

"Third. A light-gray sandy loam, with yellowish and orange streaks. The loam is sometimes of a light-yellow color. This forms the immediate banks of the Sunflower River, Tchula Lake, and is a soil of frequent occurrence. It supports a growth of sweetgum, maple, willow, oak, elm, and hackberry.

III.—*Sunflower River, front-land soil, Issaquena County.*

Insoluble matter	71.164
Silica soluble in Na O C O_2	13.506
Potash	.401
Soda	.191
Lime	.406
Magnesia	.696
Manganese, brown oxide	.011
Iron peroxide	3.845
Alumina	6.889
Phosphoric acid	.165
Sulphuric acid	.016
Volatile matter	2.748
Total	100.038

"Fourth. A light-gray clay, traversed by cracks and crumbling, where exposed to the weather, into fragments buckshot. This clay differs in color and fertility from the dark-gray buckshot clay, which has made Deer Crek so celebrated. The growth is the same as that of No. II, locality also the same—J. L. Alcorn's plantation.

IV.—*Light-gray buckshot clay, J. L. Alcorn's, Coahoma County.*

Insoluble matter	75.513
Silica soluble in *Na A O* CO_2	10.895
Potash	.606
Soda	.146
Lime	.386
Magnesia	.972
Manganese, brown oxide	.133
Iron peroxide	2.804
Alumina	4.457
Phosphoric acid	.278
Sulphuric acid	.007
Volatile matter	4.401
Total	100.598

"Fifth. A stiff, dark-gray clay, sometimes nearly black, traversed in all directions by cracks and full of streaks and dots of ferruginous matter. This is the 'buckshot' clay *par excellence*, and forms the most fertile soil in the bottom. This and the preceding are Port Hudson clays, and form the 'backlands' and surface soil of most of the swamps lying between the water courses. They are, for the most part, subject to annual overflow, though there is usually a strip one-half to three-fourths of a mile wide on the banks of the streams under cultivation. The growth is sweet-gum, over-cup-oak, willow, oak and water-oak, hackberry, pecan; near the banks of the streams an undergrowth of cane, but in the low, swampy backlands no cane, but regular cypress glades."

V.—*Deer Creek buckshot soil, Virginia Hardee place, Issaquena County.*

Insoluble matter	51.063
Silica, soluble in *Na A O* CO_2	20.707
Potash	1.104
Soda	.325
Lime	1.349
Magnesia	1.665
Manganese, brown oxide	.119
Iron peroxide	5.818
Alumina	10.539
Phosphoric acid	.304
Sulphuric acid	.024
Volatile matter	7.369
Total	100.383

Prof. F. V. Hopkins sums up his deductions from observations made in Louisiana as follows, third report, 1872, p. 189:

"1. During a long period after the deposition of the drift, the land stood at its present level, allowing the valleys to be cut in the drift that we now find covered by bluff deposits, and the earth they once contained to be restratified as the foundation for the delta. This foundation reaches above the surface of the water in Catahoulu and at Port Hudson, as far south as the Five Islands, and was covered with a forest of cypress and other trees. After a time sufficient for the accumulation of 4 feet of shady leaf-bed about the roots of these trees, a depression began and continued until the water level stood at least 68 feet above its present height at Port Hudson This would carry the area of dead water 272 miles up the river valley, allowing 3 inches to the mile as the present slope of the water in the river. So small a depression left the Mississippi very much such a stream as it now is to deposit sands and clays throughout the Port Hudson period, as at present. There occurred a further movement which left the headwaters of the river very much lower than now, while apparently not sinking Louisiana more than 25 feet further. The upper waters of the river then expanded into a lake-like estuary, almost without current as far as Fort Pierre, in Dakota, in latitude 44° 23′, and the northwest corner of Illinois. The plains of the Mississippi far and near became the swampy homes of innumerable snails, and the loess was deposited. Finally a further depression of 25 feet, in our latitude at least, and as far as Northern Mississippi, spread the area of dead water over all these swamps, and so diminished the already small current that only clayey silt could be carried by the flood. This forms our yellow loam. A reverse motion then began, which restored the height of the continent above the ocean. The rivers contracted to narrow channels, and began the work of cutting out their beds, and forming anew their flood plains and deltas—a work by no means completed. The remnants of the old flood-plains remain, a fringe of bluffs on either side, as monuments of this 'eventful history.'"

Again, in regard to the *alluvium*, he says, p. 167:

"The alluvial deposits of the Mississippi River are already classic ground for the geologist. Hastily as Sir Charles Lyell examined them in 1845, he gathered facts sufficient to form the basis of a calculation of the number of years it must have taken the river to make its present delta. (He estimates the time at 67,000 years. Second Visit to the United States, vol. 2, p. 188.) As the number was too high to suit the preconceived notions of many, there have been various efforts to reduce it. Foremost among these is that by General A. A. Humphreys, in his Report on the Mississippi River (p. 99), in which he states that the river flows, even in the delta region, 'in a channel belonging to a geological epoch antecedent to the present.' As this would greatly diminish the depth that he had assigned to the alluvium, Sir Charles Lyell appealed to the testimony of the specimens taken from the artesian well at New Orleans in 1856. These specimens were submitted to Prof. E. W. Hilgard, of Mississippi, for examination, and his report upon them appeared in the fall of 1870. The professor therein takes the view that the alluvium proper beneath New Orleans is but 31 feet thick, arguing that the marine deposits below, to a depth of 650 feet are of the Port Hudson group. I followed him last year in this idea, and quoted his list of shells under the head of the bluff formation. My observations this season oblige me to modify this conclusion somewhat. Wishing to ascertain as accurately as possible the actual depth of the alluvium, I instituted a series of experiments upon the water of the wells dug in the Port Hudson formation and in the bottom lands respectively. I have found (as, indeed, Professor Hilgard had told me that he should expect) that the former contain a considerable proportion of sulphates and carbonates while the latter show an excess of chlorides. This result is uniform excepting when the wells happen to strike considerable beds of sand, when the waters are too pure to be distinguished. It is evident, therefore, that by testing the water of the deepest wells dug in the alluvium, it is possible to tell whether they pass through it into the underlying Port Hudson groups or not. The patent wells that are made by simply driving a tube into the ground, offer great facilities for this research, as the water that they furnish comes necessarily from the bottom of the well only. On a trip that I took from Baton Rouge to the Arkansas line, I analyzed the water of various wells of from 70 to 100 feet in depth, and in not a single instance found any other than the alluvial characteristics. The alluvium, then, upon the upper part of the river being deeper, as a rule, than from 70 to 100 feet, it is highly improbable that it is no deeper than 31 at the city of New Orleans. It is true that the artesian well passed at that depth from swamp deposits into marine; the question to be decided is whether such a change is in this case a passage from one geological formation into another."

"It is not necessarily so. The term alluvium is indeed so generally confined to river formations that we are apt to forget that these are but a small part of the strata that are forming in the present era. The fine blue clay of the Mediterranean, the chalk of the "Telegraphic Plateau" of the North Atlantic, and the deposits now settling in the Gulf of Mexico from the long brown line projected into it by the mighty Mississippi, are but marine equivalents of the alluvium proper. A vast bed of such marine equivalents now lies in front of our present delta, rendering the water shallow for a distance

of 10 miles from the passes. Here occurs a sudden slope that might be regarded as the proper continental slope of the present era, so greatly does it exceed that at the shore of the delta itself. The whole sea bottom, including this shallow margin, is covered with living beings; and the recent beds, alluvial equivalents though they be, are full of their exuvial. Every advance that the delta makes in its progress toward the sea is necessarily based upon these recent beds. When, therefore, we dig through the river deposits, and come to strata with marine shells, it does not follow that we have reached an antecedent geological formation, unless the fossils are those of extinct species. Now the shells obtained beneath New Orleans are all of recent species, as far as known. There is no proof whatever, therefore, that the whole series of deposits may not be equivalents of the alluvium instead of belonging to the Port Hudson group. There are some reasons that lead to the supposition that they are very recent. The first of these has been already given, viz, that, as I have proved the river alluvium to be over 100 feet in depth at various points between Baton Rouge and Arkansas, it ought to be even deeper at New Orleans, because that city is nearer the foot of the slope of the river valley. If we grant this we are obliged to claim some of the upper marine beds as recent delta deposits, and Professor Hilgard has himself declared that no line can be drawn between these and the others. The depth of 650 feet offers no difficulty to this supposition, but rather aids the argument by completing the analogy between the bluff period and the present. I have already alluded to the continental slope that occurs 10 miles south of the passes. This slope follows the trend of the Gulf shore, almost irrespective of the protrusion of the delta. It owes its formation, no doubt, to the opposition offered by the waves of the Gulf to the outflowing current of the river. The sediment is not allowed to spread far over the Gulf bottom, but is beaten back nearly to the shore. Now this cause was in full operation during the bluff period, only, as that was a time when the river was broader than now, owing to the depression of the land, its current was less than at present, and the continental slope of that period ought to follow the general curve of the Gulf shore even more accurately than does the modern one. The land has been raised since then, and the southern edge of the prairie region, and the northern shores of Lakes Maurepas and Pontchartrain lie in about the anticipated direction. The chain of the Five Islands, however, protrudes beyond this line, so that the slope may lie nearer the city, but most probably *above it*. If so, and if the Gulf of that day was as deep near the slope as at present, New Orleans may rest upon recent deposits as thick as the Gulf is deep."

THE PORT HUDSON GROUP.

(Hopkins's 3d Report, p. 185.)

"The area of the Port Hudson group in Louisiana embraces the Bayou Maçon hills, with strips along Bayou Bartholomew and the Ouachita, Catahoula, Hollowell's, and Avoyelles prairies, with occasional terraces upon Red River, and the prairie and short-leafed pine region of Saint Landry, Calcasieu, and Lafayette upon the west of the Mississippi River. Upon the east it underlies the loess at Tunica Hills, and forms the bluffs upon the river below Bayou Sara Creek extending southeast and east throughout the Felicianas, East Baton Rouge, Livingston, Tangipahoa, and Saint Tammany. It overlies the drift where the two are in contact, and is covered itself by loess, where that is present, and by the yellow loam.

The delta formed by the Mississippi, from the end of the drift period to the era of the Loess, was composed of its strata, which are found also along the upper part of the river, at least as far as the Ohio, just as the modern alluvium forms both the newer delta, and extends, besides, to the headwaters of the river."

THE DRIFT.

(Hopkins, p. 191.)

"The drift deposit seems once to have covered our whole State (Louisiana) to a depth of nearly 200 feet. It has been removed by denudation along the Mississippi and Red Rivers, and lies buried beneath the delta accumulations of the Bluff period, probably extending far out under the Gulf. It remains upon the surface (except for the yellow loam) over the area of the tertiary deposits, extending widely east, west, and north, beyond the limits of the State. It was formed evidently by running water, the direction of the current being from the northeast and north. The main constituents are coarse rolled sand, with fossiliferous pebbles and red and yellow sandy clays, occurring in various alternations and with very irregular stratification."

In General Humphreys's Report, p. 92, he states, paragraph 2, that the "blue clay" underlies the whole Yazoo bottom, *below* the great sand stratum.

Dr. Smith says that the sand stratum is *below* it. Paragraph 3, he says, "In the bluff at Vicksburg it underlies the stratum which contains marine shells, and which Sir Charles Lyell and Dr. Harper both pronounce Eocene Tertiary, that is, the oldest Tertiary stratum,"

There is a gray or black lignitic clay in the position referred to, but it is undoubtedly Vicksburg Eocene.

Paragraph 4, he says, "It underlies New Orleans in strata alternating with sand and marine shells for at least 630 feet."

Dr. Hopkins says that the alluvium underlies New Orleans for at least 100 feet in depth, and in this I agree with him.

Paragraph 7, he quotes Lieutenant Warren as stating that this peculiar blue clay very closely resembles a formation which covers a great area in the immediate valley of the Missouri, east of the Black Hills, which Dr. Hayden assigns to the middle of the Cretaceous, where the Missouri clay undoubtedly belongs, but has no relation whatever to the blue clay of the Port Hudson period.

On page 88, he says, "The bluff at Grand Gulf is similar in height and character (to that at Vicksburg). There is the same stratum of blue clay." This clay belongs to the latter Grand Gulf period of the Tertiary. We find thus described as the same "blue clay" a clay belonging to the Cretaceous, one belonging to the Vicksburg Eocene Tertiary, one belonging to the Grand Gulf Tertiary, and an alluvial clay, and he also refers to one described by Capt. Pope in the Llano Estacado, which is probably Cretaceous, according to Prof. W. P. Blake.

SUMMARY.

The southern drift corresponds exactly in time and cause with the northern drift.

The drift succeeded immediately the Tertiary, and overlies almost its entire area, as well as that of the Cretaceous in the Atlantic and Gulf States.

Its heaviest gravel beds border the Metamorphic rocks or the Atlantic slope and as far south as Wetumpka, Ala., and, from there to the mouth of the Ohio, border the Carboniferous. On the west side of the Mississippi they border the Carboniferous in Arkansas, and extend to the Colorado River in Texas. There are other large deposits near the present bed of the Mississippi River, extending to the mouth of the Atchafalaya, which was probably the original course of the river. The drift was covered at one time in the whole delta at least as high as Memphis by a stratum of clay of Port Hudson age, which is generally blue, and is also found in rivers and creeks tributary to the Mississippi and Louisiana.

This has been to a large extent removed by the present Mississippi River at and near its present course, and may have been removed over a large portion of the bottom, and its place supplied by the alluvial deposits of the present river. The evidence furnished by General Humphreys of its forming the present bed of the river is not at all satisfactory or convincing, and does not agree with my observations. In his report, pages 91 to 95, he speaks of blue clay of no less than seven distinct geological periods, and classes them as one and the same.

The observations of Dr. Hopkins were continued for years over the whole of Louisiana, and his deductions seem to accord more nearly with the facts, certainly as to the thickness of the alluvium, which, as far as I have seen, with a few exceptions to be mentioned hereafter, is not less than 100 feet thick along the banks of the river from Memphis to New Orleans, as can be readily seen in a hundred places where the levees have been built, and in a few years have caved into the river, frequently, as on the Atchafalaya, near Simmsport, acres of land having disappeared at once, leaving a vertical wall 100 feet deep, from the bottom of which trees and logs that had been buried for ages were uncovered.

There are a few points on the river where the Port Hudson clays have resisted all the efforts of the current to dislodge them—

At Wilton Landing.

At a point opposite Grand Lake near the line of Arkansas and Louisiana.

At the mouth of Red River.

At L'Argent plantation.

At Bonnet Carré.

At New Texas landing.

I have given above extracts from those who have made a study of these Quaternary formations, which I think contain substantially every thing valuable that has been written upon them having any bearing on the question at issue. The sections which follow have been taken with care over the whole area involved, and from them you will see what value to attach to the various views expressed by the different distinguished scientists who have theorized upon this subject of such vital importance, not only to the inhabitants of the overflowed lands, but to the whole nation.

They all agree that the Loess has occupied in a past age the whole valley now covered by alluvium.

They all attribute the erosion of the valley to a swiftly flowing current of the drift period, which has left a continuous stratum of gravel and pebbles beneath the Loess.

All the later observers concur in the opinion first expressed by myself in 1867, that between the drift and the Loess there has been a continuous deposit of clay, similar to that described by Sir Charles Lyell at Port Hudson, not only in the Mississippi valley, but in the smaller tributaries.

All agree that the present river deposits annually alluvium over the whole bottom

where it is not kept within its banks by levees, and that this alluvium is in a large part of the bottom as thick as the river is deep, say 100 feet.

My observations lead me to believe that neither the banks nor the bed of the river consist of the Blue Clay of the Port Hudson period, but of clays and sand of alluvial origin.

The admirable work of General Humphreys has been a credit to the nation, and the only lack in it is the want of such geological surveys as would have shown the true age and relations of the Blue Clay, which is the subject of this report. Later investigations by admirable observers would have been rendered more valuable if they had been allowed sufficient time to study the present course and the recent and continual changes in the current of the river. I have given you the most reliable data on record, and yet this is, I fear, not what you desired—an exhaustive report on the "Blue Clay." I have studied its relations, at intervals, for twenty years, and give you the result of all that I have been able to gather from scientific records, or my own personal observation.

Respectfully,

GEORGE LITTLE.

Hon. CARLILE P. PATTERSON,
Supt. Coast and Geodetic Survey, Washington, D. C.

Feet.	Character of strata.	No.
I.—Section of bluff at Memphis, Tenn.:		
10	Yellow loam	4
40	Calcareous silt, or Loess, or Bluff	3
10	Bluish white clay	2
40	Gravel and yellow sand	1
100		
II.—Section at Crow Creek (near Madison), Saint Francis County, Arkansas.:		
25	Yellow calcareous silt.. } Bluff	7
15	Yellow loam and clay.. }	6
10	Gravel } Drift	5
10	Sand... }	4
3	Blue clay.. }	3
10	Blue mud . } Eocene	2
2	Blue clay.. }	1
75		
III.—Section at Helena, Ark.:		
6	Yellow siliceous clay marl with fossil shells	4
30	Yellow and orange sand and gravel and clay	3
20	Yellowish and whitish sand with some gravel	2
12	Space concealed to bed of slough	1
68		
IV.—Section near Sardis, Panola County, Mississippi (M. & T. R. R.):		
10	Yellow loam	....
12	Calcareous silt	....
10	Gravel and sand	....
32		
V —Section at Yazoo City, Miss:		
.....	Yellow loam	3
.....	Calcareous silt	2
.....	Bluish clay	1
VI.—Section of the Bluff at Vicksburg, Miss. (Hilgard):		
10 to 20	Calcareous silt with snails (Bluff)	7
5 to 20	Bluish and yellowish hardpan, often pebbles (orange-sand stratified drift)	6
60 to 65	Alternating strata, 1 to 6 feet thick, of limestone and marl, containing the *Vicksburg* fossils, and some bands of non-effervescent gray sand and clay	....
5	Black lignitic clay and gray sand with *Ostrea gigantea, Corbula alta, Natica mississippiensis, Cytherea sobrina, Madressora mississippiensis*	4
25	Gray or black lignitic clays or sands with iron pyrites	3
3	Solid, lustrous lignite with whitish cleavage planes	2
.....	Unknown	1
108 to 138		

Feet.	Character of strata.	No.
VII.—Section of Grand Gulf, Claiborne County, Mississippi (Hilgard):		
60 to 70	Calcareous silt of the Bluff formation forming the hill-tops	12
14	Grand Gulf sandstone, in ledges 10 inches to 2 feet in thickness	11
15	Gray sandy material, sometimes soft sandstone with an argillaceous cement, alternating with harder ledges, 6 to 10 inches thick, of friable whitish sandstone	10
2½	Solid whitish sandstone of good quality	9
2½	Greenish gray clay with white veins of carbonate of lime	8
1	Soft white sandstone	7
½	Grayish-yellow pipe-clay	6
1	Dark gray brittle sandstone	5
3	Gray semi-indurate clayey sand	4
17	Gray and yellowish sands and clays, semi-indurate, interstratified	3
3	Semi-indurate gray sand	2
2	Greenish gray clay with veins of carbonate of lime	1
121½ to 131½		
VIII.—Section at Rodney, Claiborne County, Mississippi:		
5	Yellow loam	4
100	Calcareous silt	3
5	Bluish clay	2
10	Gravel and sand	1
120		
IX*a*.—Section at Cole's Creek, Jefferson County, Mississippi, Mrs. Hunt's:		
20	Loess	2
5	Blue clay, with logs and fruit and leaves	1
IX*b*.—Section on branch of Cole's Creek, two miles from Maddox, on Fayette, Red Lick and Union Church, and Rodney roads:		
2	Loam	....
10	Mottled clay	....
2	Drift	....
2	Blue clay	....
IX*c*.—Section on —— Creek, six miles from Fayette, on Natchez road:		
5	Loamy clay	....
5	Blue sandy clay, with poplar log well preserved, Port Hudson	....
5	Blue clay, with leaves, and beach and hickory nuts	....
3	Pure blue clay, with whitish spots in bed of creek	....
IX*c*′.—Second section on same creek, below the road crossing:		
3	Loamy clay, Loess	....
5	Yellow and white sand } Drift?	....
3	Gravel } Drift?	....
5	Clay } Port Hudson?	....
2	Wood and leaves } Port Hudson?	....
3	Blue clay } Port Hudson?	....
X.—Section at Drew's Landing, one mile above L'Argent Landing, below mouth of Fairchild's Creek, ditch 800 yards across bend:		
6	Sand	4
2	Sandy clay	3
5	Clay with little sand	2
5	Blue clay	1
XI.—Section at Natchez, Miss.:		
100	Gray calcareous silt of the Loess or Bluff formation, with helices and calcareous concretions	5
2	Brown loam, resembling surface soil, but calcareous	4
50 to 60	Orange and yellow sands with some gravel } Orange sand or stratified drift.	3
15	Ledges of ferruginous puddingstone and coarse sandstone } Orange sand or stratified drift.	2
15 visible	Blue clayey sand and sandy clay of the Grand Gulf group	1

Feet.	Character of strata.	No.
XII.—Section at Ellis Cliffs, 12 miles below Natchez:		
30	Loess	2
76	Orange sand	1
XIII.—Section at Buffalo Creek:		
20	Loam and silt	2
5	Blue Clay, with mastodon skull and teeth	1
XV.—Section at Loftus Heights, Fort Adams, Miss. (Hilgard):		
72	Yellowish gray calcareous silt of bluff formation	3
87	Orange sand, yellow, orange, and white sand	2
170	Argillaceous sandstone, yellowish gray in its mass, variegated with ferruginous spots and veins, and of different degrees of hardness, so as to weather into rough, jagged surface. Traceable to water's edge	1
XVI.—Section below Fort Adams, at Warehouse Landing:		
150	Loess	3
40	Orange sand	2
40	Claystone	1
XVII.—Section at Barker's, 7 miles east of Fort Adams:		
15	Loess	2
50 to 75	Orange sand	1
XVIII.—Section 15 miles east of Fort Adams:		
1 to 5	Yellow loam	....
.....	Gravel	....
XIX.—Section 21 miles east of Fort Adams, and 4 miles from Woodville, Miss.:		
5	Yellow loam	5
20	Orange sand	4
8	Reddish hardpan and pebbles	3
2	Blue clay	2
10	Red, yellow, and white hardpan	1
XX.—Section on Thompson's Creek, at McGehee's:		
10	Loess	2
5	Blue clay	1
XXI.—Section at Red River Landing:		
5	Alluvial soil	4
3	"Buckshot" clay	3
40	Blue clay with sand and "buckshot"	2
.....	Quicksand and very little gravel	1
XXII.—Section at junction of Atchafalaya and Red Rivers:		
5	Gray sand	2
25	Red clay	1
XXIII.—Section at Tunica, La. (Hopkins), and opposite Tunica:		
5	Alluvium	4
.....	Loam	3
150	Loess	2
5 feet below surface	Blue clay with stumps	1
XXIV.—Section on Tunica Bayou, 3 miles back of Tunica:		
10	Loess	3
20	Sand and gravel	2
10	Clay	1
XXV.—Section 6 miles from Tunica, and 2 miles from Pinkneyville:		
10	Loess	5
5	Red clay	4
20	White sand	3
20	Mottled clay	2
5	Blue clay	1
XXVI.—Section at Saint Francisville:		
10	Yellow loam	4
9	Sand	3
5	Sandy silt	2
2	Blue clay	1

Feet.	Character of strata.	No.
XXVII.—Section at Port Hudson, near saw-mill (Hilgard):		
4 to 6	Yellow surface loam	6
25	Yellow hardpan	5
7	Heavy greenish clay	4
6	Gravel, sand, and clay in irregular bands like river alluvium, with pebbles, drift-wood, leaves, and mastodon bones	3
25 visible	Heavy greenish and bluish massy clay similar to No. 4	2
.....	.....	1
XXVIII.—Section at Port Hudson, Alton Landing (Hopkins):		
5	Yellow loam	8
20	Hardpan, white and yellowish	7
21	Bluish joint clay	6
24	Sand	5
3	Ferruginous clay	4
13	Blue clay (massive)	3
4	Blue shale (stumps)	2
3	White clay	1
XXIX.—Section midway between Port Hudson and Fontania (Hilgard):		
8 to 10	Yellow loam, sandy below	6
18	White and yellow hardpan	5*a*
8 to 15	Orange and yellow sand, sometimes ferruginous—sandstone	5
7	Heavy greenish or bluish clay	4
18	White indurate silt and hardpan	3
30	Heavy green clay, with porous calcareous concretions above, ferruginous ones below, some sticks and impressions of leaves	2
3 to 4	Brown muck / White or blue clay } with cypress stumps	1
XXX.—Section at Allworth's, 5 miles north of Baton Rouge:		
17	Hardpan, white and yellowish	3
11	Sand	2
24	Blue clay	1
XXXI.—Section at Baton Rouge, United States Arsenal (Hopkins):		
23½	Yellow loam	3
15	Hardpan	2
16½	Blue clay	1
XXXII.—Section at Garig's Ferry, Amite River, 12 miles east of Baton Rouge:		
5	Yellow hardpan	3
10	Whitish hardpan	2
5	Blue clay	1
XXXIII.—Section at Bonnet Carré Crevasse:		
100	Alluvium	
.....	Blue clay, dredged from river bottom	
XXXIV.—Section at Bayou Manchac:		
.....	Close, stiff clay in its bed	
XXXV.—Section at New Orleans:		
2	Surface soil	11
15	Clay, blue, tenaceous, uniform	10
3.8	Clay, coal black, containing rootlets, woody matter, &c.	9
10.2	Sand and clay mixed, subtile, like the annual deposits of Mississippi River	8
10	Clay	7
0.7	Sand	6
1.3	Shells	5
33	Sand	4
6.5	Shells	3
29	Clay and sand	2
34	Clay (Port Hudson period?)	1
XXXVI.—Section at Lake Borgne:		
25	Dark swamp clay, sea marsh	12
25	Bluish tough clay, fresh water	11
10	Blue clayey sand, fresh water	10
17	Drab-colored sand, fresh water	9
31	Blue clay, fluvio-marine	8
.....	Coarse gray sand, fresh water	7

Feet.	Character of strata.	No.
XXXVI.—Section at Lake Borgne—Continued.		
.....	Grayish clay, fluvio-marine	6
.....	Blue sandy clay, marine	5
16	Greenish micaceous sand, marine	4
.....	Drab or blue tenaceous clay, fluvio-marine	3
.....	Drab or bluish sand, fluvio-marine	2
34?	Drab or bluish clay, marine, Port Hudson?	1
XXXVII.—Section at Avera's Bluff, Chickasawhay River, Green County, Mississippi (Hilgard):		
15	Yellow sand, with silicified wood (drift)	2
15	Compact, bright blue clay (Grand Gulf)	1
XXXVIII.—Section at Dwyer's Ferry, Pascagoula River, Jackson County, Mississippi (Hilgard):		
2	Yellowish indurate clay—"Flatwoods clay"	5
4	Gray sand, with yellow dots containing particles of lignite and crystals of gypsum	4
7	Gray sandy clay, with lignitic layers, traces of leaves, and crystals of gypsum	3
4	Blue massy clay, with crystals of gypsum	2
12	Stratified gray clayey sands, cleaving into layers one to six inches thick	1
XXXIX.—Section at Bayou Bernard:		
?	Sand?	....
8	Dark bluish-black clay, tenaceous, fetid, and irregularly stratified with *Ostrea Virginica*, *Balanus*, *Mytilus Harmatus*	....
XL.—Section at Sancier's, Wolf River, Harrison County, Mississippi (Hilgard):		
20	Gray and yellow sand, stratified, more or less clayey, especially below	3
2 to 3	Yellowish gray massy clay	1
7 to 8	Matrix of dark gray or black clayey sand or muck, inclosing trunks, stumps, roots, and knees of cypress, with bark and wood preserved; also, a few pine burrs	1
XLI.—Section at Mrs. McRae's, West Pascagoula, Miss. (Hilgard):		
10 to 15	Sand	3
10	Sky-blue clay	2
?	Gray, calcareous, water-bearing sand, containing abundance of shells (Hilgard)	1
XLII.—Section at Sam Powe's, near Winchester, Miss.:		
18	Yellow sand, with pebbles in its lowest portion (orange sand)	5
1½	White sand, with nodules of pipe-clay	4
1 inch	Black clay, with leaves	3
1	Grayish white sand, with vestiges of leaves or stratification lines	2
5	Bluish sandy clay, with roots and trunks of *Capuliferæ*, *Coniferæ*, *Palmæ*.	
XLIII.—Section at Sicily Islands, Louisiana:		
20	Yellow loam	4
24	Loess	3
26	Drift gravel	2
30	Grand Gulf	1
XLIV.—Section of Corley's well, near head of Catahoula Lake, Louisiana:		
11	Yellow loam	4
7	Fine yellow sand	3
§ inch	Salt in crystals	2
38	Blue clay, with cypress bark, limestone nodules, and fresh-water shells of recent species	1

TABLE 1.—*Formations, sections, and localities.*

Number of section			1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Periods and formations.			Memphis.	Madison.	Helena.	Sardis.	Yazoo City	Vicksburg.	Grand Gulf.	Rodney.	Cole's Creek.	Fayette (?) Creek.	Drew's Landing.	Natchez.	Ellis' Cliffs.	Buffalo Creek.
1	Alluvium	Quaternary	....	....	....	....	....	....	....	....	....	....	13	....	....	....
2	Loam	Quaternary	10	....	....	10	....	....	....	5	2	5	....	....	....	20
3	Loess	Quaternary	40	40	6	12	....	20	70	100	20	....	....	100	30	....
4*a*	Port Hudson Hardpan	Quaternary	....	....	....	....	....	....	....	....	....	....	....	....	....	....
4*b*	Port Hudson Blue Clay	Quaternary	10	....	....	....	....	....	....	5	10	13	5	....	....	5
5	Drift	Quaternary	40	20	50	10	....	20	....	10	4?	....	....	75	76	....
6	Grand Gulf	Tertiary	....	....	....	....	....	....	61.5	....	....	....	....	15	....	....
7	Vicksburg	Tertiary	....	....	....	....	....	98	....	....	....	....	....	....	....	....
8	Red Bluff	Tertiary	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9	Jackson	Tertiary	....	15	....	....	....	....	....	....	....	....	....	....	....	....
10	Claiborne	Tertiary	....	....	....	....	....	....	....	....	....	....	....	....	....	....
11	Mansfield	Tertiary	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	Cretaceous		....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	Carboniferous		....	....	....	....	....	....	....	....	....	....	....	....	....	....
14	Devonian		....	....	....	....	....	....	....	....	....	....	....	....	....	....
15	Silurian		....	....	....	....	....	....	....	....	....	....	....	....	....	....

Number of section			15.	16.	17.	18.	19.	20.	21.	22.	23.	24.
Periods and formations.			Fort Adams.	Below Fort Adams.	Barker's, 7 miles east of Fort Adams.	Fifteen miles east of of Fort Adams.	Four miles from Woodville.	Thompson's Creek.	Red River Landing.	Atchafalaya, Red River, and Junction.	Tunica.	Tunica Bayou, 3 miles back.
1	Alluvium	Quaternary	.....	.....	.....	.....	.....	.....	5	5	....	.....
2	Loam	Quaternary	.....	.....	.....	5	5	.....	.....	.....	....	.....
3	Loess	Quaternary	72	150	15	.....	.....	10	.....	.....	150	10
4*a*	Port Hudson Hardpan	Quaternary	.....	.....	.....	.....	.....	.....	.....	.....	....	20
4*b*	Port Hudson Blue Clay	Quaternary	.....	.....	.....	.....	.....	.....	.....	25	....	10
5	Drift	Quaternary	87	40	75	.....	40	.....	(?)	.....	....	.....
6	Grand Gulf	Tertiary	170	40	.....	(?)	.....	.....	.....	.....	....	.....
7	Vicksburg	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	....	.....
8	Red Bluff	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	....	.....
9	Jackson	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	...	.....
10	Claiborne	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	....	.....
11	Mansfield	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	....	.....
12	Cretaceous		.....	.....	.....	.....	.....	.....	.....	.....	....	.....
13	Carboniferous		.....	.....	.....	.....	.....	.....	.....	.....	....	.....
14	Devonian		.....	.....	.....	.....	.....	.....	.....	.....	....	.....
15	Silurian		.....	.....	.....	.....	.....	.....	.....	.....	....	.....

TABLE 1.—*Formations, sections, and localities.*—Continued.

Number of section			25.	26.	27.	28.	29.	30.	31.	32.	33.	34.
Periods and formations.			Six miles from Tunica.	Saint Francisville.	Port Hudson, near sawmill.	Port Hudson—Alton Landing.	Port Hudson to Fontania.	Allworth's, 5 miles north Baton Rouge.	Baton Rouge United States Arsenal.	Garig's Ferry, Amite River.	Bonnet Carré.	Bayou Manchac.
1	Alluvium	Quaternary	....	...	.....	.....	.....	.....	.....	.....	100	20?
2	Loam	Quaternary	....	10	6	5	10	.....	23.5	.....	.....	.....
3	Loess	Quaternary	10	.....	.....	.....	.....	.....	.....	.....	.....	.....
4a	Port Hudson Hardpan	Quaternary	25	14	25	20	33	28	15	15	.....	.....
4b	Port Hudson Blue Clay	Quaternary	25	2	38	68	59	24	16.5	5	?	?
5	Drift	Quaternary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	Grand Gulf	Tertiary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	Vicksburg	Tertiary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	Red Bluff	Tertiary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Jackson	Tertiary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10	Claiborne	Tertiary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	Mansfield	Tertiary	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	Cretaceous		....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	Carboniferous		....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	Devonian		....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	Silurian		....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Number of section			35.	36.	37.	38.	39.	40.	41.	42.	43.	44.
Periods and formations.			New Orleans.	Lake Borgne.	Avera's Bluff, Green County, Mississippi.	Dwyer's Ferry.	Bayou Bernard.	Sancier's Bluff.	West Pascagoula.	Winchester, Miss.	Sicily Islands, La.	Catahoula Lake, La.
1	Alluvium	Quaternary	112	124	.....	.....	.....	.....	.....	.....	.....	....
2	Loam	Quaternary	.....	.....	.....	.....	.....	.....	.....	.....	20	11
3	Loess	Quaternary	.....	.....	.....	.....	.....	.....	.....	.....	24	....
4a	Port Hudson Hardpan	Quaternary	.....	.....	.....	11	.....	.....	.....	.....	.....	7
4b	Port Hudson Blue Clay	Quaternary	34	34?	.....	16	.....	.....	.....	.....	.....	38
5	Drift	Quaternary	.....	.....	15	.....	.....	20	15	19.5	26	....
6	Grand Gulf	Tertiary	.....	.....	15	.....	8	11	10	5?	30	....
7	Vicksburg	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
8	Red Bluff	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
9	Jackson	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
10	Claiborne	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
11	Mansfield	Tertiary	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
12	Cretaceous		.....	.....	.....	.....	.....	.....	.....	.....	.....	....
13	Carboniferous		.....	.....	.....	.....	.....	.....	.....	.....	.....	....
14	Devonian		.....	.....	.....	.....	.....	.....	.....	.....	.....	....
15	Silurian		.....	.....	.....	.....	.....	.....	.....	.....	.....	....

APPENDIX Q.

A MEMOIR TO ACCOMPANY THE MAP OF MISSISSIPPI COUNTY, ARKANSAS.

[Compiled by Frank L. James, M. D., Ph., D., for the Mississippi River Commission, 1881.]

INTRODUCTORY.

§ 1. On the map accompanying this memoir, I have endeavored, by conventional means, to represent the topography of the region as it existed at the time of the compilation of the map (January, 1879), gleaning my data from various authentic sources of

information, the basis being the field-notes of the United States surveys of 1848 and '49, modified and corrected by surveys made by myself and others, during the years of 1874, '75, 77, and '78. I have taken the flood of 1874 as a basis of reference for most of the statements and conclusions made by me, because I traveled over almost every portion of the region during that overflow. Acting in the capacity of agent for parties who owned large bodies of land situated in various parts of the county, and who contemplated making extensive improvements, in the way of levees and drainage, I paid particular attention to the depth of overflow, direction of currents, &c., thus accumulating a mass of information not to be obtained in any other manner, and all of which I have embodied in the map herewith presented.

§ 2. The region formerly known as Mississippi County, but now embracing parts of Craighead and Poinset Counties, constitutes the extreme northeastern portion of the State of Arkansas. Extending from the Saint Francis to the Mississippi River, it has an average width of twenty-four miles, its length from north to south being thirty-eight miles. Its frontage on the Saint Francis River is sixty-seven miles, and on the Mississippi seventy-nine miles. Its area, according to the United States surveys, is 1,122 square miles, or 718,400 acres. Of this area, only about 35,000 acres, or not one-twentieth part, are above ordinary high-water level, the balance being subject to an almost annual submergence, the depth of which varies from a few inches to twenty feet, and even more—the average, according to approximate estimates, being something over four feet—and requiring more than 5,000,000,000 cubic yards of water for its submergence. To describe in brief the general topography and the physical characteristics of this region, and to explain the methods by which the same is flooded and drained, is the object of this memoir.

I.

§ 3. THE TOPOGRAPHICAL FEATURES of the region may be classified as follows, viz:

1st. *The bottoms*, those areas which are submerged during the period of high water only, their level of overflow subsiding almost synchronously with that of the river from which the water came, and which are consequently dry during the greater part of the year.

2d. The ponds, sinks, brakes, and swamps, which, from defective drainage, retain more or less of the overflow, and which are covered with water the greater portion of the year, but are sometimes dry.

3d. Those lakes, ponds, and holes which alway retain a greater or less volume of water, and are never dry.

4th. The water-courses.

5th. The highland or land above overflow.

a. The bottoms comprise by far the greater part of the region, having an area of about 600,000 acres. They are intersected in every direction by rivers, bayous, sloughs, &c., which serve both as inlets and outlets of the overflow.

On the map herewith presented, the approximate depth of overflow of these bottoms, as gleaned from the field-notes of the old United States surveys, is shown by small Arabic numerals and by shading. The direction of currents is shown by small arrows. As will be explained hereafter (§ 22), the measurements of overflow-depths of the old United States surveys have been very much modified and altered by events which have occurred since the surveys were made.

b. Ponds, brakes, and swamps.—While these formations are individually very small, the aggregate area covered by them is very considerable. I estimate it to be at present about 17,500 or 18,000 acres, which, however is much less than their area as deduced from the government surveys. Owing their origin to various causes, their physical aspect is varied. Some of them are open and grown over with sedge, coarse grasses, flags, and various species of *nymphæa*, while others are thickly grown up with gigantic cypresses, gums, and other swamp vegetation. The largest of these cypress glades or brakes is shown on the map in township 12 north, range 11 east. These ponds have generally no outlets or drainage, and the level of the water in them is affected solely by evaporation.

c. The lakes proper are numerous, and owe their origin to distinct causes, which affect their present physical aspect, and easily distinguish them into classes as follows:

1st. Those caused entirely by earthquake action; 2d, those caused by the spreading out of existing streams; and, 3d, those which are the remains of old river beds, bends, &c., left by the Mississippi River, as its channel has gradually shifted to its present position. Most, if not all, of the two last classes have been materially modified by seismic action (except, of course, those of the last class which have been formed since the period of great earthquake disturbance).

§ 4. The area of the lakes proper, according to the United States surveys, is about 55,000 acres, but from the operation of causes treated of at length hereafter (§ 22) the area actually covered by water, at all times, is very much less—probably not over

one-third so much. Even this estimate may be too high, as the submerged surface has been rapidly decreasing during the last eight years.

§ 5. *The lakes which owe their origin solely to seismic action*, usually termed "earthquake lakes," or "sunk lands," came into existence during the great convulsions of 1810–'11–'12. They are mostly confined to the western portion of the county, toward the Saint Francis basin, and cover a total area of about 13,000 acres. The general aspect of these lakes is dreary and forbidding in the extreme. Their beds are full of dead trees, very few of which are left standing, the great majority having been thrown down and twisted in every direction during the seismic convulsions, and now lying, partly or wholly submerged, in the black mud and water. The vegetation at present growing around them consists of stunted willows, privet and grease-wood. These lakes have usually no outlet. They are of no very great depth. I am not aware that any systematic series of soundings has ever been made in them.

§ 6. *The lakes caused by the spreading and widening* of existing rivers (from earthquake and other action) are the largest and most important sheets of water. There are several of considerable size, the aggregate area of which, according to the United States surveys, made in 1847–'48, is 84½ square miles. The actual area covered by water at the present time is, as remarked above, much less—probably not over 40 square miles—and is constantly decreasing. The largest of these bodies of water, and by far the most important, is Big Lake, which has an extreme length, from north to south, of 14½ miles, its width being from 4 to 6 miles. Through this lake meanders Little River, a navigable stream, as shown in the accompanying map. In 1848, the area covered by water, at all times, was 27,200 acres, which is reduced to barely 12,000 acres at present. At the foot of this lake there is a "hole" or basin, some 25 acres in extent, called the Gar Hole, the average depth of which is from 20 to 50 feet deeper than that of any other portion of the lake. I was informed several years ago by an old half-breed, who claimed to have been a witness of the convulsions, that this "hole" was, prior to 1811, dry land; but that one day during the winter of 1811—the "great earthquake winter"—it suddenly rose some distance in the air, and then subsided to its present condition, being immediately filled with water from Little Red River and Pemiscot Bayou. The western banks of Big Lake are above overflow, and present the largest body of high land to be found in Mississippi County. Next in size and importance to Big Lake is *Tyronza Lake*, formed by the spreading of Tyronza River or Bayou and by the drainage of a series of flats or openings extending northward, parallel to the Mississippi River, for many miles, and called, in local parlance, the "*Scatters of Tyronza.*" The contour and bed of this lake were also very much altered by earthquake action. Its area, as laid down on the map, is 6,560 acres. The actual surface covered by water is probably not more than 4,000 acres. Tyronza differs from all the other lakes of this series in not having any very considerable body of high land on its borders. The other important lakes belonging to this series are Carson's, Golden's, Young's, Buford's, Clear, Dead Timber, Swan, and Round Lakes, and numerous smaller bodies of water that have no distinct appellation. Their aggregate area, according to old surveys, is 16,500 acres; the actual area, always covered by water, being about a third of that. *All of these lakes* have their western banks above overflow. The average depth of water in them is from three to seven feet.

§ 7. *The lakes which are the remains of old river beds* are characterized by their narrowness (as compared to their length), their crooked shape, and their depth. Such are Long Lake, Crooked Lake, Walker's Lake, &c., as shown on the accompanying map. The aggregate area of these lakes in 1877 was about 5,000 acres. They lie contiguous to and, generally, parallel with the Mississippi River. They are generally connected with each other and with the river by sloughs and bayous, which are sometimes wide and deep.

§ 8. *The Cypresses.*—In addition to the above general subdivisions there is one more, which properly belongs to "The Bottoms," but the especial and distinguishing features of which are so peculiar as to demand separate notice. By reference to the accompanying map a series of depressions will be noted, commencing at or near the Saint Francis River and running north and south, parallel to the general course of that stream. They are almost straight, and are designated on the map by the names by which they are generally known to the hunters and trappers who frequent these regions, as Honey Cypress, Cockle-burr Cypress, Buffalo Cypress, &c. They are longitudinal depressions in the bottoms, varying in length from ten to twenty miles, and in width from one-eighth to one-half mile. Their depth below the general level of the surrounding bottoms varies from 10 to 30 feet, their banks being almost invariably abrupt. As their name would indicate, they are heavily timbered with cypress trees, many of which have attained a considerable size. In times of overflow they become virtually channels of the Saint Francis River, a large body of water pouring through them. Taking on their water above, and emptying it below directly into the Saint Francis River, they become dry as soon as the level of that stream subsides below that of their bottoms, and they remain dry during the greater portion of the year. Their fall corresponds very closely to that of the Saint Francis, so that

rain-water very rarely accumulates in them, and never stands for any length of time—though a small rivulet of clear water is generally found trickling through them during all but the driest months of the year. From close examinations of these formations, I am satisfied that they owe their existence to earthquake action, having been formed probably at the same time, and by the same convulsions, that made Hatchie Coon Sunk Lands, Saint Francis Lake, Bark Camp, and Led Fork Overflow, &c.

II.

§ 9. The water courses of this region belong to two classes, viz: Those whose current runs in one direction at all times; and, 2d, those, the direction of whose current is dependent upon the state of the stream or basin with which they communicate, flowing in one direction while the water is rising, and in the opposite when it is falling.

§ 10. The first class numbers four or five important streams, viz: Little River, Tyronza River, Buffalo Creek, Pemiscot Bayou, and Frenchman's Bayou. The three first empty into the Saint Francis. Pemiscot empties into Little River, and Frenchman's Bayou into the Mississippi. The most important of these is Little River, not only on account of its length, but of the part it plays in flooding and draining the bottoms through which it flows. Having its source in Perry, Bollinger, and Cape Girardeau Counties, in the State of Missouri, it flows southward a hundred miles or more into the southern portion of New Madrid County, Missouri, as a narrow stream. Here it is joined by the Castor River, and the two continue southward, under the name of Little River, the course continuing to widen out as it flows through Pemiscot and Dunklin Counties, until in the latter, some eighteen miles from the Arkansas line, it spreads out and forms Big Lake. Through this it flows by tortuous channels, emerging at the extreme southern point of the lake and continuing its course through Mississippi County, Arkansas, and finally emptying into the Saint Francis River, a few miles below Saint Francis Lake—over 160 miles in a straight line from its sources. The extreme crookedness of its channel makes its length not far from 250 miles. It has direct communication with the Mississippi River twice in this distance—once by Portage Bayou, between Pemiscot and New Madrid Counties, Missouri, and again by Pemiscot Bayou. On emerging from Big Lake, and directly opposite to the point where it is joined by Pemiscot Bayou, it sends forth an arm or forms a delta, a portion of its waters starting for the Saint Francis by an independent channel, which has the appearance on the map, to which reference is made, of being a continuance of Pemiscot Bayou, and presenting the singular spectacle of two rivers crossing each other.

§ 11. The "*right-hand chute*" of Little River, as the new stream is called, flows towards the Saint Francis, gradually growing shallower and smaller, until it loses itself in the deep overflow known as Bark Camp Overflow. The average width of Little River proper (the left-hand chute of the map) is from 125 to 200 feet. Small steamers navigate it from its mouth to the head of Big Lake, and even higher.

§ 12. *Buffalo Creek* also rises some distance up in Missouri, and flows southward between the Saint Francis and Little Rivers. It differs from all the other small streams in this region in having a constant flow at all times, never going dry even in the longest periods of drought. It loses itself, like the right-hand chute of Little River, in Bark Camp Overflow.

Tyronza Rirer has its head in Carson's Lake, flowing thence to Tyronza Lake, which is formed partly by the spreading out of this stream, and thence by the most tortuous of channels into the Saint Francis, which it reaches near the mouth of the Arkansas. That portion of Tyronza River which flows through the region we are now describing has an average width of 132 feet (2 chains). Its current, except in overflow, is so sluggish as to be hardly perceptible. *Frenchman's Bayou* arises in Butler's Lake, and flows southward through Swan Lake and empties into the Mississippi River. Its total length is about eighteen miles. It has little or no current except during and immediately after an overflow.

§ 13. *Pemiscot Bayou* is a tortuous, though wide and comparatively deep, canal or channel, which makes out from the Mississippi River in Pemiscot County, Missouri, having two mouths, one near Gayoso, and the other at Cottonwood Point. It runs in a southwesterly direction, and communicates with several lakes in its course to Little River, which it empties into exactly at the foot of Big Lake. Its length from Cottonwood Point to its debouchement is about thirty miles, its average width being two chains. A very large amount of the overflow-water taken from the Mississippi by the Pemiscot does not reach Little River, but is deflected into Walker's, Buford's, and Grassy Lakes, and finds its way back into the Mississippi via Long Lake and Mill Bayou.

§ 14. All the balance of the bayous, sloughs, etc., belong to the second class; *i. e.*, those that serve both as inlets and outlets of overflow. The most important, so far as the volume of water conveyed by it is concerned, is Mill Bayou, which helps to fill the great basin of overflow described in § 16. As in the case of the lakes, there is usually, indeed always, more or less high land on the banks of these bayous and rivers, being generally found on the west side.

III.

§ 15. A general overflow of this region is effected by a combination of phenomena, and the methods by which it is accomplished are always more or less modified by the circumstances attending the particular rise in the Mississippi which causes the flood. Thus, while certain portions of the basin are always filled by a direct influx from that river, and certain others are always filled from the Saint Francis and Little Rivers, there is a large area which is sometimes flooded from one and sometimes from the other source, or from both combined. Thus, in the annexed imaginary profile, A rep-



resents a trough always filled by direct overflow from the Mississippi; C and D represent troughs always filled by the waters of Little River and the Saint Francis, while B is filled sometimes by direct overflow from the Mississippi (through A), and at other times receives part, if not all, of its waters from C and D, the source of supply depending on the condition of those streams (Little River and Saint Francis) when the rise in the Mississippi takes place. If these streams are low and the rise in the Mississipi is rapid, the troughs A and B are filled by direct overflow before the overflow taken on by the Saint Francis and Little Rivers at or near their headwaters can have time to fill their own troughs, or basins, to overflowing. But if these smaller rivers have been swollen by local rains and come down "bank full" at the same time that the Mississippi is rising, they fill their own basins and run over into B before the overflow from the latter river does.

§ 16. *The area* flooded directly by the Mississippi is estimated by me to be about 360 square miles. It lies immediately contiguous to the river and has an average width of 7 or 8 miles. The largest basin is in the upper portion of the county, extending from the comparatively high land northwest of Osceola to Pemiscot Bayou, and from Walnut Ridge (west of Clear Lake) to the high land on Little River, a distance of about 12 miles each way. The average depth of this basin is 7 feet. It is filled through three great main channels, viz, Pemiscot (through Walker and Hudgins Lake), the low banks below Barfield, and Mill Bayou. This basin embraces the so-called "Scatters of Tyronza," and through them the overflow passes into the basin of Tyronza Lake, joining the floods that have poured into the southern portion of the county through the low banks below Osceola, Young's, Carson's and Golden's lakes. A great deal of this overflow is very shallow.

§ 17. *The Little River Basin* receives its water through that river, which takes on the overflow of that vast submerged region west of Cairo, which embraces the counties of Scott, Stoddard, Mississippi, New Madrid, Dunklin, and Pemiscot, in Missouri. The flood also pours into it through Portage and Pemiscot Bayous. The area of this trough or basin (in Mississippi County, Arkansas), including Big Lake, is about 400 square miles. If there should have been a rainfall in this region immediately preceding the overflow, sufficient to fill the ponds and bottoms connected with this system, and to make Little River "high," the overflow spreads very rapidly and fills up the entire region between Tyronza on the one side and Buffalo Cypress on the other. The average depth of this overflow is difficult to arrive at, as there are many very deep holes, limited in area but capable of holding a great deal of water. There are also many narrow ridges of comparatively high land, generally disposed in a direct direction parallel to the rivers, but sometimes running from east to west. When the overflow begins to subside, Tyronza River plays a very important part in the drainage and carries off an immense volume of water. A large part of this overflow finds its way back into the Mississippi through Frenchman's Bayou (Swan Lake Bayou), Dead Timber Lake, and Wappenochee. The greatest part, however, goes by Little River into the Saint Francis.

§ 18. *The area flooded by the Saint Francis* lies between the high lands west of Big Lake and Little River and the Saint Francis, and comprises an area of 250 square miles, in the midst of which arise the highlands known as Buffalo Island. The floods in the Saint Francis are modified by the same local causes and phenomena as those described in the preceding paragraph as affecting Little River. To this system belong the "Cypresses" described in § 8, which become, during the period of high water in that river, virtually parts or channels of the Saint Francis. The deep and extensive depression known as Bark Camp Overflow, which owes its origin to earthquake action, also belongs to this basin, although it receives water from the so-called right-hand chute of Little River and from Buffalo Creek. The average depth of overflow here is very great—not less than 8 or 10 feet.

§ 19. *The duration of an overflow*, or the length of time during which the bottoms remain covered with water, obviously depends on so many extraneous circumstances

that it is impossible to assign an exact average. During a residence of ten years in this region, however, I found that the great body of land called "The Bottoms" was dry from nine to ten months of every year, while a large proportion is dry even longer than that. In the deeper bottoms the contrary condition obtains, and some of them do not dry off for four or five months.

IV.

§ 20. The area of land protected by levees, shown on the map by being tinted yellow, is about 36,000 acres. The largest amount in any one body is situated around the town of Osceola, where there is, including a small amount of naturally high land, some 25,600 acres. It lies along the river somewhat in the shape of a crescent, fronting with its hollow side Plum Point Bend, and extending from Morgan's Point on the south to Mill Bayou on the north. The average height of levee necessary to protect this body of land is 8 feet. The other points similarly protected, as shown on the map, are the Upper Lanier, Nodena, Stonewall, Lower Lanier, and Pecan Point places, and a portion of Shawnee Village. There remains along the river in this county considerable of the old State levee, the exact amount of which, however, I have at hand no means of ascertaining, having lost my memoranda or given them to the officer detailed by the United States Government to ascertain these facts several years ago. I would remark that the condition of these old levees, such as are now standing, is in the main good, and they would require comparatively little work to put them in order. (This remark does not apply to the rebuilding of gaps which exist, but simply to the repairing of those fragments still standing.)

§ 21. *Besides the levees of modern construction* there are thickly scattered over this region mounds and earthworks, many of them of considerable extent, the remnants of an ancient and extinct civilization, attesting in an eloquent manner the occupancy in former times of these now deeply overflowed bottoms by a teeming, industrious, and ingenious population. The largest of these earthworks are to be found on Pemiscot Bayou, Big Lake, Chickasaba and Frenchman's Bayou, and on the Shawnee Village plantation, though there is no part of the county but what some form of mounds or earthworks may be found, even in the deepest overflows. In the delta of Little River, immediately after its exit from Big Lake, may be found evidences of an immense settlement, extending for 15 or 20 miles down the stream. On the banks of the river and in the bed of the stream near the banks hundreds of wagon loads of fragments of pottery and baked clay may even now be gathered up, while the erosion of its banks by the stream is constantly uncovering new deposits, burial cysts, &c., containing pots, vases, basins, and other household articles of pottery ware, stone implements, ornaments, &c., some of which are of artistic design, beautiful workmanship, and high finish. I have at various times sent collections of these relics of ancient civilization to the Smithsonian Institution, at Washington, D. C., where they are now deposited. The careful examination of numerous skeletons uncovered by the erosive process spoken of above, and exhumed by myself at different times from mounds and burial places, has satisfied me that they belonged to a race differing very materially from the subsequent occupants of the soil (the red Indians), and that a very long period of time has elapsed since the interments were made. Chemical analyses, of which I have made several, establish the fact that but a minute proportion of gelatine remains in the bones undissolved, and a comparison of this percentage of residue with the amount of gelatine found in bones taken from ancient Italian, Etruscan, Roman, Greek, and British ossuaries of an approximately known age, and similarly situated in regard to moisture of soil, &c., would indicate an antiquity of at least two thousand years. The only bearing that these facts have upon the subject-matter of this memoir is to show that the bed of the Mississippi River has not occupied this region in very recent times.

V.

§ 22. *Changes in the general level of the country.*—As has been intimated elsewhere, numerous changes have taken place in the topography of this region since its survey by the United States Government in 1848 and 1849, the field-notes of which have hitherto served as the only authority in the compilation of maps and for all subsequent surveys.

§ 23. The agencies which have effected these alterations are twofold, and while both have operated towards the accomplishment of one effect, *i. e.*, the elevation of the general level of the surface of the region, they differ widely in character and mode of action—the one acting comparatively slowly but continuously, while the other performed its work in one mighty effort.

§ 24. The first of these agencies is that of *sedimentary deposits.* Its effects are most apparent in Big Lake, Clear Lake, and the other smaller lakes of the northern end of the county. On the accompanying map the contour lines indicate the size and shape

of these bodies of water as they were at the time of the survey alluded to, while the "vegetation" shows the extent to which the lakes have filled up since that time. Old inhabitants who have watched the rate of growth say that it has been far more rapid in the last few years than ever before. What the causes for this increase in the rate of deposit are, we have no means of knowing, though it has occurred to me that it is partly, at least, owing to the fact that the country through which the upper parts of Little River, Buffalo Creek, and the Saint Francis flow is becoming yearly more cultivated, and the soil broken up by plows, unprotected by forest, &c., is washed out and carried down in far greater quantities than ever before. On Shawnee Valley plantation, in the lower end of Mississippi County, there was a small lake that maintained a constant depth of water for many years, so long, indeed, as it was surrounded by forests. In 1873 the proprietor of the plantation opened the wood adjoining it, and planted the fields in corn. The lake soon commenced to grow shallower, and is now almost completely dry—filled up with the rich black surface soil of the adjacent fields, which was washed off and carried into the lake by rains and overflow water.

The extent of this filling-up process can only be estimated by me approximately, as stated in § 4. I think that there is not now over one-third of the area permanently covered by water that there was in 1848—though only a portion of this result can be attributed to sedimentary deposit.

§ 25. *The event* which had more to do with the alteration of the level, and consequently of the general appearance of this region, than any other phenomenon that has occurred in recent times, not excepting the earthquakes of the early part of the century, was the *Devil's Elbow Cut-off*, which happened in 1876, with the general history of which the Commission is familiar. The writer hereof was at Shawnee Village, distant about 10 or 12 miles from the point where the cut-off was made, in an air-line, and he distinctly felt the shock and heard the roar of the mighty mass of water as the river cut its way through the narrow neck of land that had hitherto restrained it, and plunged at one leap down the descent which it had formerly crawled 25 miles to make. The immediate result of this cut-off was to check the rise in the river for a hundred miles upstream. At Osceola the river fell 22 inches in a few hours, and that, too, on a rapidly-swelling stream. It drained Golden's Lake and the bottoms between it and Frenchman's Bayou, and lowered the level of Young's and Carsons Lake's and Tyronza from 4 to 6 feet. The deep bottom between Shawnee Village and Frenchman's Bayou was drained almost completely, and where there were formerly impassible sloughs is now dry land. The drainage of Golden's Lake was more thorough than that of any other portion of the county. Where formerly there was a sheet of water of nearly 4,000 acres in area, and of a depth of 8 to 10 feet, there are now only a few isolated water holes of limited area, the balance of what was once the bed of the lake being now a prairie-like opening, covered with rank grasses and vegetation of all sorts. A portion, if not all, of this old lake-bed has been homesteaded, and it will soon be in cultivation.

§ 27. *The changes in the coast lines* or meanders of the Mississippi River, other than the one above alluded to, have been numerous and important, and it was originally my intention to show upon the map herewith submitted the present coast line of the river, as established by recent surveys, as well as the line of the old surveys, so that these changes could be seen at a glance. Circumstances have, however, prevented my accomplishing this, and I am compelled to omit such graphic representation, at least for the present.

§ 28. These changes have been caused both by erosion and accretion. In Hickman's Bend (township 15 north, range 13 east) both agents have been at work most actively. At least 3 square miles have been added to the point in section 12 (township 15 north, range 13 east of fifth principal meridian), while quite that much has been eaten away from the bend below it (Barfield). The bank in front of the northern half of the town of Osceola has been eroded two chains (132 feet) since 1850, while there has been no change in the front of the southern half of the town. There has been about 100 feet (1½ chains) eaten away from the front of sections 15 and 16, township 12 north, range 11 east (Sans Souci place), and considerable change at Morgan's Point (same township and range). The next locality of considerable change is in township 11 north, range 10 east, in front of sections 26, 27, 28, 32, where there has been an erosion of from 100 to 700 feet, as shown on the map, where both lines, the old one and the present, are given.

§ 29. *The meanderings and coast lines of the internal streams* are correctly laid down on the map. The changes in these lines have been very slight, recent surveys made by the writer with improved instruments only verifying the correctness of the old surveyors. The only corrections which had to be made were in some of the bends of Little River and Tyronza, and these were unimportant.

All of which is respectfully submitted.

FRANK L. JAMES, M. D.

NOTE.—The map referred to in this memoir is too large and complicated to be reduplicated at reasonable expense. The memoir is thought of sufficient general interest, aside from the map, to warrant the trifling expense of printing.—S. S. L.

APPENDIX R.

REPORT OF BOARD OF OFFICERS UPON REPAIRS OF LEVEES.

NEW ORLEANS, LA., *December* 2, 1882.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President pro tem. of the Mississippi River Commission:

SIR: The Board of Officers convened by Special Orders No. 88, Headquarters Corps of Engineers, Washington, D. C., August 29, 1882, for the transaction of certain business connected with the repair and building of levees on the Mississippi River, have the honor to make the following report:

The Board met at Memphis, Tenn., September 4, 1882. Maj. B. M. Harrod, a member of the Mississippi River Commission, and Capt. Clinton B. Sears, Corps of Engineers, its executive officer, were present at several meetings of the Board, to represent to the Board the aims and wishes of the Commission.

The duties and powers of the Board are set forth in the resolutions of the Mississippi River Commission, at their meeting in New York, August 17 and 18, 1882, which, being approved by the Secretary of War, were referred to the Board by the letter of the Chief of Engineers, dated August 29, 1882. These resolutions and instructions are hereto attached.

Preliminary to any distribution of the undistributed allotment for levees, Mr. Harrod explained to the Board the topography of the Yazoo and Tensas bottoms, the system and design of the levees of the two fronts, and, from the map, the present condition of the levees, and the views of the Commission with reference to the closing of existing breaks and crevasses.

It is not considered necessary in this report to enter into a description of the topographical features of the river fronts, which are well known and understood, but the requirements of the drainage areas of the Tensas and Yazoo bottoms were considered by the Board, to enable them to properly distribute the funds for the closure of gaps along their fronts.

The State engineer of Louisiana and of the Mississippi Levee Board, second district, submitted to the Board their surveys and estimates, and various surveyors, engineers, and parties interested in giving information to the Board presented more or less accurate information.

After reducing all the estimates received to the requirements of the orders under which the Board acted, the following estimated quantities of work to be executed appeared:

YAZOO FRONT.

In the first Mississippi district, extending from the hills at the head of the Yazoo basin to Hushpuckana Creek, there is no levee organization.

	Cubic yards.
The estimated amount of work in this district up to the requirements of the Commission, as made by the county surveyors of De Soto and Tunica Counties, and by Mr. Hewson, civil engineer of Coahoma County, is	1,035,081
In second district, estimated from the surveys of the Chief Engineer, Mississippi Levee Commissioners	1,560,443
Total Yazoo front	2,595,524
Arkansas, Desha, and Chicot Counties, estimated by Colonel Sapington	1,050,000
Louisiana above Red River, from State engineer's surveys and estimates, deducting State contracts	3,121,600
Total Tensas front	4,171,600
Atchafalaya front	576,200

The Board having determined the relative amount of work in the river front selected by the Commission for improvement, then proceeded to inquire into the funds available from the States. Financial statements were presented by the State engineer of Louisiana, which showed nothing available in that State not needed below Red River and in other levee districts.

In Mississippi, in first and second districts, exclusive of work done by the Mississippi Levee Commissioners and land damages	$42,000
In Arkansas	30,000

Taking into consideration these sums, and the amount of work to be done, the Board recommended to the Commission the division of the unassigned portion of the levee allotment, as stated in the letter of the Board to the president of the Commission, which was as follows:

"In obedience to their instructions the Board of Engineer Officers, convened by Special Orders No. 88, Headquarters Corps of Engineers, U. S. A., Washington, D. C., August 29, 1882, have the honor to recommend to the Commission the following distribution of the $350,000, which was the remainder of the allotment of $1,300,000 not distributed by the Commission, viz:

To Yazoo front	$140,000
To Tensas front	150,000
To Atchafalaya front	60,000

Making the total allotment to each front—

Yazoo	440,000
Tensas	750,000
Atchafalaya	110,000
Total	1,300,000

as allotted.

It is the opinion of the Board that these sums will not be more than sufficient to close existing gaps to former grades, that is, that there will be no surplus for carrying new work above former grades.

The resolutions of the Commission, by which the Board have been guided, provided that certain specified amounts should be applied to certain points, and that the Board should recommend the division of the remaining $350,000.

In your letter of August 29 to the Chief of Engineers it is stated that it was the sense of the Commission that the amount allotted to the front below Red River might be increased to a maximum of $100,000. The Board have recommended the amount of $110,000 in order to carry the work down to cover the Point Coupée crevasse, as this appeared to be the intent of the resolution.

The Board have reached their conclusions from a careful comparison of the estimated amount of work and available funds on all of the fronts, as ascertained from the most reliable information to be obtained on such short notice.

Having considered all the data it was practicable to collect respecting the condition of the levees within the limits proposed, the Board concluded at its first session to advertise for bids for closing the gaps and crevasses on the Louisiana side from Point Coupée crevasse to the Arkansas line, and within the limits of the second Mississippi district, leaving the same openings as heretofore at the foot of the Yazoo and Tensas fronts for the natural drainage of those basins, viz, from Black Hawk to Red River on the Tensas front, and from a short distance below Chotard to the Yazoo on the Yazoo front. The quantities estimated in these limits were based on reliable data.

The information with regard to the gaps along the Arkansas front below White River and in the first Mississippi district was considered too vague and indefinite to justify advertising at that time. The officers in charge of the levees in these limits were requested meanwhile to have accurate surveys and locations made.

In accordance with these views an advertisement was ordered to be inserted in the papers selected by the Engineer Department, which advertisement and specifications for the work, which were prepared by the Board, are attached hereto.

The bids submitted to the Board of Engineers on the 25th day of September, and the action of the Board approved by the Secretary of War, are shown in the tabulated statement attached hereto. The bids received making it very evident that the allotments of funds for the closure of gaps and crevasses and repair of the levees are insufficient to close the gaps advertised in Louisiana along the Tensas and Atchafalaya fronts, the Board sought to cut down the amount of work to be done to within the sums allotted, and after consideration it was decided by the Board that in declining to close gaps they would adhere to the following rules:

1st. To throw out or reject breaks at the lower extremities of the Tensas and Yazoo fronts, inasmuch as the escaped water returns entirely to the Mississippi on the Yazoo front, a few miles below, and on the Tensas front also, except so far as it may escape down the Atchafalaya.

2d. Between two or more crevasses allowing equal quantities of water to escape, to close the recent in preference to the old crevasses, for the reason that the river has already accommodated itself to the conditions imposed by the old crevasses, while the new ones may cause damage to navigation from the changes of regimen due to their influence.

3d. Between new crevasses discharging equal quantities of water, to close those covering the most extended river front and within the amounts allotted.

In accordance with this decision and having in view the facts stated further on in

this report, concerning the levees in Arkansas and at the head of Yazoo Basin, the Board decided to decline bids on the following levees, under the present allotment:

1st. In Mississippi, second district: Chotard, 30,000 cubic yards at foot of the Yazoo system.

2d. In Louisiana, below Red River: Morganza crevasse; but this crevasse may be closed if sufficient State aid is procured to supplement the balance of the appropriation by the United States.

3d. In Louisiana, above Red River, Bougiere crevasse at foot of Tensas front, Castleman's to Buck Ridge, including the Diamond Island crevasses, reduced to 30,000 cubic yards for the recent breaks near Point Pleasant. This is thrown out, not only because discharging less water than other large crevasses above, considered more important, but also because the State engineer of Louisiana informed the Board that the discharge of water can probably be partly controlled by the State authorities.

Ashton crevasse and Lake Providence Reach, reduced to 60,000 cubic yards to close the Elton or Hopewell break, leaving Ashton, an old crevasse, open. This crevasse is left out because in addition to its being a crevasse of long standing (seventeen years), the Board were assured by the citizens of Desha and Chicot Counties, Arkansas, that if the United States would close the large breaks below Arkansas City, including Duffin's Break, estimated then at 60,000 cubic yards, Panther Forest, 175,000 cubic yards, and Whiskey Chute, 80,000 cubic yards, the local authorities would complete the levees from the high ground back of Cypress Creek, about 20 miles above and back of Arkansas City, as far down as to Matthews Bend, extending over about 50 miles of river front and covering the breaks at the heads of Bayous Maçon, Bœuf, and Bartholomew, which flood with escaped water eleven parishes of Louisiana, and produce the shoal bars at Choctaw Bend, and Leland Crossing below Greenville.

It was considered by the Board that if all the water of the Mississippi River, except what escaped over the banks in the part of the Yazoo front above Friar's Point (or Sheriff's Ridge), could be concentrated again at Arkansas City, reinforced by the Arkansas water, and held as far down as Matthews Bend, the quantities discharged by the deteriorated, filled-up, willow-grown crevasses at Matthews Bend and Ashton would be small in comparison with that escaping around the heads of the Bœuf, Bartholomew, and Maçon; and that, consequently, in addition to improving, by scour, the lower end of Choctaw Bend, just above Arkansas City, and the Leland Crossing, below Greenville, there would still, under the existing conditions, with Ashton open, be a larger quantity of water retained through the Lake Providence Reach than with Ashton closed and the crevasses above open.

We give in so much detail the considerations that influenced the Board in throwing out Ashton crevasse, after favorable bids were received for closing it, because on the Yazoo front the line of levee repaired by the action of the Board is continuous, practically, from the foot of the district to the high ground at Friar's Point, and on the Louisiana or Tensas front, from the Bougiere crevasse, above Red River, to Arkansas City, except the breaks from Matthews Bend to the foot of Ashton crevasse; and because the leaving of the crevasse open is seemingly in opposition to the design of the Commission to concentrate the waters of the river at the obstructed points especially, at the head of one of which, the Lake Providence Reach, the Ashton crevasse is situated; and also, in seeming disregard of the theory of making the lines continuous from the lowest point upward. In further reducing the quantities advertised to be let, it was considered by the Board that 68,000 cubic yards could safely be dropped from the advertised amounts for the construction of Hole in the Wall and Waterproof gaps, and at Upper Delta, at which places the State engineer of Louisiana has favorable contracts which he can execute. In place of this, 60,000 cubic yards were added to the Kempe levee. Also in Mississippi, second district, revised estimates and better locations, showing that the following quantities could be reduced, the reduction was ordered:

Parker's enlargement and breaks, 180,000 reduced to 100,000 cubic yards.

Clay and Baggott's to Roland's, 217,000 reduced to 177,000 cubic yards.

Longwood, 86,000 reduced to 70,000 cubic yards.

Shiloh to Tennessee, 70,000 reduced to 40,000 cubic yards.

The work for the following-named levees was advertised by circular letter, by authority of the Secretary of War, the bids received having been considered unsatisfactory, viz:

Louisiana, Tensas front:

	Cubic yards.
Kempe Break and Extension	340,000
Shipp's Bayou to Hard Times	183,000
Between Castleman's and Buck Ridge, near Point Pleasant	30,000
In Mississippi:	
Roland's to Jenkins	175,000

The last-named levee was accidentally omitted from the first advertisement, and for the others bids had been received which were considered too high.

An abstract of the second letting, September 29, is also hereto attached.

Upon the face of the abstracts is written the action of the Board, which has been approved, by telegraph, by the Secretary of War. At the second session of the Board the following contracts were awarded:

List of contracts awarded by the Board of Engineers, September 25 and 29, 1882, and approved by the Secretary of War, October 2, 1882.

MISSISSIPPI—YAZOO FRONT.

Contractor.	Locality.	Cubic yards.	Per cubic yard.	Total.
			Cents.	
Mayer & Co	Magna Vista to Chotard's	50,000	22	$11,000
Arnold & Co	Shiloh to Tennessee	40,000	24¾	9,900
Hugh Carlisle	Elleslie	111,000	20	22,200
W. B. Strang & Co	Skipwith	91,000	18	16,380
	Longwood	70,000	18	12,600
James Madden	Jenkins to Easton	84,000	24¾	20,790
Clay & Miller	Roland to Jenkins	175,000	28½	49,875
Fruin & Co	Clay and Baggott to Roland's	177,000	29	51,330
	Wade Break	97,000	24	23,280
	Hughes Breaks	22,000	24	5,280
	Beulah to Hughes	152,000	28	42,560
	Beulah Enlargement	107,000	29	31,030
Scott & Lamb	Beulah 1 to 9	32,000	28	8,960
W. B. Strang & Co	Riverton Break	172,000	18	30,960
McGavock & Tate	Parker Enlargement	100,000	32	32,000
J. W. Eldridge	Lake Charles Break	30,000	25	7,500
				375,645

LOUISIANA, ABOVE RED RIVER—TENSAS FRONT.

R. G. Huston & Co	Green's to Fairview	373,000	28	$104,440
Kiernan & Phelan	Lake Concordia Breaks	301,000	18	54,180
P. J. Kennedy	Kempe Extension	340,000	28½	96,900
G. A. Meyer	Hardscrabble and Bondurant	330,000	28	92,400
P. G. Meath	Shipp's Bayou to Hard Times	183,000	28	51,240
James Madden	Castleman's to Buck Ridge	30,000	20	6,000
Hugh Carlisle	Upper Delta to Bedford	248,000	23	57,040
L. Madden	Sparta above Duckport	42,000	18½	7,770
J. B. Reid	Milliken's Bend to Cabin Teele	96,000	19	18,240
Hugh Carlisle	Omega to Milliken's Bend	190,000	21	39,900
Mayer & Co	Raleigh to Willow Point	50,000	22	11,000
R. G. Huston & Co	Wilton to Raleigh	390,000	24	93,600
J. B. Reid	Lake Providence Reach	60,000	22	13,200
				645,910

LOUISIANA, BELOW RED RIVER—ATCHAFALAYA FRONT.

G. A. Meyer	Atchafalaya River to Red River Landing	94,000	22½	$21,150
N. W. Irish	Hog Point to Raccourci	60,000	26	15,600
C. L. Hardeman	Raccourci Crevasse	84,000	24	20,160
G. A. Meyer	Stewart Crevasse	9,200	24½	2,254
G. A. Meyer	Pointe Coupée Crevasse	120,000	25	30,000
				89,164

The estimate for felling timber is not given, as the amount is unknown, even approximately. At the session of the Board on October 16, W. R. Strang stated to the Board that his bid, opened September 25, on the Riverton Break, was made upon a misrepresentation by the State engineers of the character of the work, and that upon visiting the locality he found it utterly impracticable to do the work at 18 cents per cubic yard, the price named in his bid. After considering the case, it was deemed proper by the Board to recommend that the contract be awarded to J. F. Stokes at 27 cents. This was approved, and added $15,480 to the amount of contracts on Yazoo front.

Having estimated the probable cost of the levees already awarded, Riverton as subsequently awarded, and having received more definite data, the following levees were

advertised in Arkansas and Coahoma County, Mississippi—bids received October 16, 1882:

	Cubic yards.
In Arkansas:	
Duffin Break	60,000
Panther Forest	175,000
Whiskey Chute	80,000
In Coahoma County, Mississippi; below Friar's Point:	
From Garth's to Jefferson's	95,000
From Bland's Bayou to Garland's	66,000

The breaks in Arkansas were advertised for considerations already stated, and in Mississippi because that by carrying the levees to Friar's Point a high ridge above overflow could be reached, upon which to rest the upper flank of the Yazoo levees. This ridge is not at the head of the Yazoo Basin, but in connection with the levees retains in the river considerable amounts of water that would otherwise flank the northern extremity of the levees of the second Mississippi district, and be carried over into the Yazoo River.

The levees from Friar's Point to the second Mississippi levee district are left open at the foot of Hushpuckana drainage area because the amount available for levees above the second Mississippi district was not sufficient to cover the whole distance to Friar's Point, and this opening would allow the natural drainage of that small independent basin to flow into the Mississippi River through the Lewis Swamp or Hushpuckana Creek without damage.

The upper part of Hushpuckana Creek, which drains naturally into the Yazoo, has been crossed by the levees of the second district and its drainage turned into the Mississippi through an artificial cut which the Board still leaves open.

List of contracts for levee work recommended for award October 18, 1882, *and confirmed by the Secretary of War October* 23, 1882. *Bids received October* 16, 1882.

1. IN ARKANSAS—TENSAS FRONT.

Contractor.	Levee.	Cubic yards awarded.	Price per cubic yard.	Clearing per acre.	Total for earthwork.
Winters & Walsh	Duffin Break	87,000	$0 24¾	$40 00	$21,352 50
Street & Craig	Panther Forest	175,000	25	70 00	43,750 00
No bid	Whiskey Chute				
	Total				65,102 50

Cost of clearing not estimated.

Inasmuch as there were no bids for Whiskey Chute and the amount remaining for the Tensas front is not more than sufficient to pay engineering and contingencies and for felling timber, it was not deemed prudent by the Board to readvertise Whiskey Chute or to attempt further work on the Tensas front.

2. IN MISSISSIPPI—YAZOO FRONT.

Contractor.	Levee.	Cubic yards.	Price per cubic yard.	Felling per acre.	Amount of earthwork.
Timothy Sullivan	Garth to Jefferson's	95,000	$0 22	$75 00	$20,900 00
Arnold & Company	Bland's Bayou to Garland's	66,000	24¾	75 00	16,335 00
	Total				37,235 00

Felling timber not estimated.

Total amount of levee contracts let by the Board of Engineers, September and October, 1882, for earth work only; timber not estimated:

For Tensas front	$711,012
For Yazoo front	428,360
For Atchafalaya front	98,164

Leaving for engineering, surveys, felling timber, and contingencies:

On Tensas front	$38,988
On Yazoo front	11,340
On Atchafalaya front	20,836

It is considered by the Board that the excess on the Atchafalaya front not contracted for may be supplemented by State aid, and the Morganza crevasse closed; that the deficiency in contingent fund for the Yazoo front will be supplied by reduction of the known liberal estimates and by relocation of lines where caving banks will probably be prevented, and that the surplus on the Tensas front will not more than meet the requirements of the contracts made along that front for clearing timber, surveys, and contingencies.

AMOS STICKNEY,
Major of Engineers, United States Army.
A. M. MILLER,
Captain, Corps of Engineers.
W. L. MARSHALL,
Captain of Engineers.

The following papers are transmitted with the report of the Board, viz:

1. Copy of special order convening Board.
2. Copy of letter of instructions from Engineer Department, dated August 29, 1882.
3. Copy of letter with additional instructions to Board from Chief of Engineers, dated August 30, 1882.
4. Copy of letter from president of Mississippi River Commission to Chief of Engineers, dated August 29, 1882
5. Extracts from Proceedings of Mississippi River Commission furnished Board for guidance.
6. Abstract of bids opened September 25, 1882.
7. Abstract of bids opened September 29, 1882.
8. Supplement to Nos. 6 and 7.
9. Abstract of bids opened October 16, 1882.
10. Supplement to No. 9.
11. Copy of specifications prepared by Board for levee work.

AMOS STICKNEY,
Major of Engineers, U. S. A.

R 1.

1.—ORDER CONVENING BOARD OF OFFICERS.

[Special Orders No. 88.]

HEADQUARTERS CORPS OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 29, 1882.

By direction of the Secretary of War a Board of Officers of the Corps of Engineers, to consist of Maj. Amos Stickney, Capt. Alexander M. Miller, Capt. William L. Marshall, will assemble at Memphis, Tenn., on Monday, September 4 proximo, or as soon thereafter as practicable, for the transaction of certain business connected with the building and repair of levees on the Mississippi River, instructions concerning which will be furnished by this office. On completion of this duty the members of the Board will return to their stations. This travel is necessary for the public service.

By command of Brigadier-General Wright.

(Signed) H. M. ADAMS,
Captain of Engineers.

Maj. AMOS STICKNEY,
Corps of Engineers, New Orleans, La.

2.—LETTER OF INSTRUCTIONS TO BOARD OF OFFICERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 29, 1882.

SIR: There is sent herewith a copy of Special Order No. 88, Headquarters Corps of Engineers, Washington, August 29, 1882, convening a Board, of which you are the senior member, to meet at Memphis, Tenn., on the 4th September proximo.

There are also sent copies of certain resolutions adopted by the Mississippi River Commission in relation to levees, which, having been approved by the Secretary of War, are furnished for the guidance of the Board, and to indicate the duties for which it is convened.

The Secretary of War has also approved the recommendation of this office, in this connection, that the Board, or the individual officers, invite proposals for the construction and repair of levees in the following newspapers without further instructions, viz:

Picayune and Times-Democrat, New Orleans, La.
One newspaper in Natchez, Miss.
One newspaper in Vicksburg, Miss.
One newspaper in Greenville, Miss.
One newspaper in Helena, Ark.
One newspaper in Memphis, Tenn.
One newspaper in Cairo, Ill.
Republican and Globe-Democrat, in Saint Louis, Mo.

The time for opening the bids will be so fixed as to allow of full ten days' advertisement in each of the newspapers in the above list.

Should it be found necessary for the Board to visit the localities of the levees to be constructed or repaired, such visits will be made without further orders.

By command of Brigadier-General Wright.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Lieutenant-Colonel of Engineers, Bvt. Maj. Gen., U. S. A.

Maj. AMOS STICKNEY,
Corps of Engineers, Senior Member Board of Engineers, &c., New Orleans, La.

3.—SUPPLEMENTARY INSTRUCTIONS TO BOARD OF OFFICERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., August 30, 1882.

SIR: Referring to letter to you from this office of yesterday's date, there is sent herewith for the information and guidance of the Board of Officers of the Corps of Engineers, constituted by Special Order No. 88, Headquarters Corps of Engineers, current series, of which you are the presiding officer, copy of a letter and its inclosure, from the president of the Mississippi River Commission, inclosing copy of resolution of the Commission, adopted August 28, 1882, recommending that $50,000 be set aside from the contingent allotment for building and repairing levees on the Mississippi River, for purpose of closing outlets and crevasses below Red River, discharging into the Atchafalaya and its basin, &c.

By command of Brigadier-General Wright.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Lieutenant-Colonel of Engineers, Bvt. Maj. Gen., U. S. A.

Maj. AMOS STICKNEY,
Corps of Engineers, New Orleans, La.

4.—INCLOSURE TO NO. 3.

ARMY BUILDING,
NEW YORK, *August* 29, 1882.

GENERAL: I have the honor to inclose a copy of a resolution of the Mississippi River Commission, adopted August 28, 1882, which I have to request may be communicated to the Board of District Engineers, to be convened at Memphis on 4th prox., for their information and guidance.

It will be seen that in this resolution the Commission modify their previous recommendation concerning the repairs to levees below Red River, insomuch as concerns those on the right bank that cut off the Mississippi overflow from the Atchafalaya, or, say as far down as Plaquemine. To this portion of the river front $50,000 is alloted by the inclosed resolution, and it is the sense of the Commission, as developed in the discussion thereon, that this amount may be increased, from the unalloted balance for levee work, to a maximum of $100,000, at the discretion of the

Board of District Engineers. The provisional allotment for levee work will therefore stand as follows:

Right bank between Arkansas and Red River	$600,000
Right bank below Red River	50,000
Left bank on Yazoo front	300,000
Contingent on future allotment	350,000
Total	1,300,000

I am, general, very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieutenant-Colonel of Engineers, Bvt. Maj. Gen'l U. S. A.,
President Mississippi River Commission.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A., Washington, D. C.

5.—INCLOSURE TO NO. 4. EXTRACTS FROM PROCEEDINGS OF THE MISSISSIPPI RIVER COMMISSION AT ITS SESSION IN NEW YORK CITY, AUGUST 14, 1882.

* * * * * * *

Resolved, That the Commission considers it expedient that the work of closing existing gaps in levees should commence at the lower end of the Tensas and Yazoo basins, leaving a sufficient opening for the natural drainage, and also for accidental overflow in the upper parts of the respective fronts.

While it is considered that in general a levee system should be built from below upwards, yet in view of the greater obstruction to navigation and the probable deterioration produced by the late flood along the front of the Tensas and Yazoo bottoms, it is under these circumstances considered advisable to commence levee works as above stated.

The relief afforded by such decision will place it in the power of the State engineer departments to make increased provision for other parts of the levees, and it is therefore recommended that the Louisiana levee fund be expended below Red River, and that of Mississippi at the upper end of Yazoo bottom. (Adopted August 17, 1882.)

* * * * * * *

Moved, That in order to secure an equitable distribution of the funds allotted for levee repairs, the Commission recommend that the officers in charge of the three lower districts be convened as a Board at Memphis on the 28th inst., or at as early a date as practicable, to confer with the State engineers of Lousiana, Mississippi, and Arkansas, to go over the river front from Memphis to Red River if deemed necessary, to examine personally into the plans and estimates of the State engineers, and any other reliable information available, and to recommend to this Commission a final allotment of the unallotted balance based upon closing all gaps within the limits specified in previous resolutions to the level of the old grade, allowing for such sums as may be available from State sources; also that Major Harrod and Captain Sears represent the Commission at this Board: *Provided*, That the Board be directed to ascertain and report whether after closing all gaps to the level of the old grade any raising of this grade in new work will be justified by the amount of funds available; to what extent this work may be carried, and at what localities it could most advantageously be done. (Adopted, August 18, 1812.)

* * * * * * *

Resolved, That it is further recomended by this Commission that it is advisable that the first application of the allotment for closing existing gaps be directed to closing them all to former grade, in conjunction with the assistance rendered by the States, and that should there be any surplus after this it should be applied to raising grades of new work as may be advised by the Board of District Engineers ordered to meet at Memphis. Also that a copy of this be sent to said Board. (Adopted, August 18, 1882.)

* * * * * * *

Whereas the following estimates have been furnished by gentlemen representing the levee organization and interests of Louisiana, Mississippi, and Arkansas:

Cubic yards of earthwork required to repair existing breaks to former grade.

	Cubic yards.
Right bank below Arkansas River	5,864,000
Left bank below Norfolk	1,714,000

Therefore,

Resolved, That we recommend the following provisional allotment:

Right bank between Arkansas and Red River	$600,000
Left bank on Yazoo front	300,000
Contingent on future allotment	400,000
	1,300,000

This allotment is made under the representation that the following funds are available in the different States:

Louisiana, $70,000 for Fifth Louisiana Levee District.
Mississippi, $200,000 for Second Mississippi Levee District.
Arkansas, $30,000, Colonel Sappington, of Arkansas City.
(Adopted, August 18, 1882.)

* * * * * * *

Resolved, That we recommend to the Secretary of War that authority be granted to the district officers in charge of the works of construction on lower river to accept surveys made by State engineers * * * whenever in the judgment of said officers it is advisable and advantageous to the United States so to do.

Resolved, That it is recommended that the sum of $50,000 be set aside from the contingent allotment for building and repairing levees for closing the outlets and crevasses below Red River discharging into the Atchafalaya and its basin; such sum to be applied to the closure of such outlets as are nearest Red River, and divert the largest quantities of water from the Mississippi.

(Adopted.)

6.—*Abstract of proposals for levee work received in response to the following advertisement, opened September 25, 1882, by the Board of Engineers, convened by Special Orders No. 88, Headquarters Corps of Engineers, dated Washington, D. C., August 29, 1882.*

LEVEE WORK.

NOTICE TO CONTRACTORS.

Sealed proposals in duplicate will be received till 12 o'clock noon, September 25, 1882, at United States Engineer's Office at Memphis, Tenn., for construction or repair of levees on Mississippi River in the States of Louisiana and Mississippi, as follows, viz:

LOUISIANA BELOW RED RIVER.

	Cubic yards.
From Atchafalaya River to Red River Landing, about	122,000
From Hog Point to Raccourci, Old River, about	74,000
Raccourci Crevasses, about	84,000
Morganza and Stewart Crevasses, about	175,000
Pointe Coupée Crevasse, about	120,000

LOUISIANA ABOVE RED RIVER.

Bougiere Crevasse, about	200,000
From Green's to Fairview, about	373,000
Lake Concordia Breaks, about	301,000
Hole in the Wall and Waterproof Gaps, about	38,000
Kempe Extension, about	280,000
Hardscrabble and Bondurant, about	330,000
Shipp's Bayou to Hard Times, about	183,000
From Castleman's to Buck Ridge, about	285,000
Upper Delta to Bedford, about	278,000
Sparta, above Duckport, about	42,000
Milliken's Bend to Cabin Teele, about	96,000
Omega to Milliken's Bend, about	190,000
Raleigh to Willow Point, about	50,000
Wilton to Raleigh, about	390,000
Ashton Crevasse and Lake Providence Reach, about	272,000

MISSISSIPPI.

Chotard's, about	30,000
Magna Vista to Chotard's, about	50,000
Shiloh to Tennessee, about	70,000
Elleslie, about	111,000
Skipwith, about	91,000
Longwood, about	86,000

6.—*Abstract of proposals for levee work received in response to the following advertisement, opened September 25, 1882, &c.*—Continued.

	Cubic yards.
Jenkins' to Easton, about	84,000
Clay and Bagott to Roland's, about	217,000
Wade Break, about	97,000
Hughes' Break, about	22,000
Beulah to Hughes', about	192,000
Beulah enlargement and Clear Creek Break, about	107,000
Beulah Breaks, 1 to 9, about	32,000
Riverton Break, about	172,000
Parker's enlargement and breaks, about	180,000
Lake Charles Break, about	30,000

Work above these points will be advertised when more definite information is obtained. Information respecting localities and character of work in Louisiana may be obtained at office of Board of State Engineers, New Orleans, La.; in Mississippi at office of Engineer of Mississippi Levee Board, Greenville, Miss.

Bidders must furnish a bond of 25 per cent. of the amount of their bids, that they will enter into contract within five days of notification of award of contract. Contractors must furnish a similar bond for execution of contract.

Blank forms and instructions to bidders may be obtained by addressing United States Engineer Office at New Orleans, La., or Memphis, Tenn.

Proposals must be made on forms furnished. The United States reserves the right to reject any or all bids.

Proposals must be addressed to Maj. Amos Stickney, President Board of Engineers, United States Engineer Office, Memphis, Tenn., and marked on outside of envelope "Proposals for Levee Work."

Number of proposals.	Names of bidders.	Locality of levee.	Number of cubic yards.	Price per cubic yard.	Price of felling timber.	Remarks. (See also the abstract by localities, following, No. 8.) All proposals more or less informal.
1	W. B. Strang & Co., Kansas City, Mo.	Skipwith		$0 18	Cost and 9 per cent	New construction.
		Longwood		18	do	Do.
		Riverton Break		18	do	Do.
		Do		19½	do	For repairs on present old levee.
2	George Arnold, Memphis, Tenn	Chotard Levee		24	$800, entire line	Embankment and excavation.
	Charles F. De Garis, Greenville, Miss.	Magna Vista to Chotard		23	$500, entire line	Do.
		Elleslie Levee		21	Nothing	Do.
3	T. C. Hicks, Helena, Ark	Longwood Levee, Miss		24½	$40 per acre	Embankment.
		Do		23		Excavation.
4 A	R G. Huston, Cincinnati, Ohio	Bougiere Crevasse		35		
		Green's to Fairview		28		
	John B. Neely, Chattanooga, Tenn	Lake Concordia		27		
		Hole in the Wall and Waterproof Gaps		27		
		Kemp Extension		38		
		Hardscrabble and Bondurant		35		

		Shipp's Bayou to Hard Times		34		
		Castleman's to Buck Ridge		36		
		Upper Delta to Bedford		29		
		Sparta above Duckport		25		
		Milliken's Bend to Cabin Teele		25		
		Raleigh to Willow Point		24		
		Wilton to Raleigh		24		
		Ashton Crevasse and Lake Providence reach.		35		
				35		
		Elleslie, Miss		28		
		Skipwith		28		
		Longwood		26		
4 B	R. G. Huston, Cincinnati, Ohio	Bougiere Crevasse		35		
		Green's to Fairview		28		
	John B. Neely, Chattanooga, Tenn	Lake Concordia		27		
		Hole in the Wall and Waterproof Gaps		27		
		Kemp Extension		38		
		Hardscrabble and Bondurant		35		
		Shipp's Bayou to Hard Times		34		
		Castleman's to Buck Ridge		36		
		Upper Delta to Bedford		29		
		Sparta to Duckport		25		
		Milliken's Bend to Cabin Teele		25		
		Raleigh to Willow Point		24		
		Wilton to Raleigh		24		
		Ashton Crevasse and Lake Providence		35		
		Elleslie, Miss		28		
		Skipwith		28		
		Longwood		26		
		Chotard		36		
		Magna Vista to Chotard		36		
		Shilo to Tennessee Landing		34		
		Jenkins' to Easton		35		
		Clay and Baggott to Rolands		35		
		Wade Break		35		
		Hughes' Break		33		
		Beulah to Hughes'		35		
		Beulah enlargement to Clear Cleek		36		
		Riverton Break		38		
		Parker's Enlargements and Breaks		37		
5	M. W. Hughes, Vicksburg, Miss	Milliken's Bend to Cabin Teel		21		Excavation.
		Do		21	$18 per acre	Embankment.
	J. B. McGinty, New Orleans, La	Upper Delta to Bedford		24		Excavation.
		Do		24	$35 per acre	Embankment.
		Lake Concordia Breaks		21		Excavation.
		Do		21	$25 per acre.	Embankment.
6	E. F. Miller, Bolivar Landing, Miss.; Green Clay, Bolivar, Miss.	Clay and Bagot's to Roland's in Bolivar County, Miss.		34	$50 per acre or $500 felling timber on whole line.	
7	J. W. Eldredge, Lake Charles Landing, Miss.	Repair of Lake Charles Break		30		Excavations.
		Do		25	$80 per acre	Embankments.
8	E. F. Miller, Bolivar Landing, Miss.; Green Clay, Bolivar, Miss.	Wade Break in Bolivar County, Miss		26	$50	

6—*Abstract of proposals for levee work received in response to the following advertisement, opened September* 25, 1882, *&c.*—Continued.

Number of proposals.	Names of bidders.	Locality of levee.	Number of cubic yards.	Price per cubic yard.	Price of felling timber.	Remarks. (See also the abstract by localities, following, No. 8.) All proposals more or less informal.
9	Hugh Carlisle, Talladega, Ala	Sparta, above Duckport, La		$0 20	Cost, and 10 per cent. additional.	
		Milliken's Bend to Cabin Teele, La		20		
		Omega to Milliken's Bend, La		21	do	
		Raleigh to Willow Point, La		24	do	
		Wilton to Raleigh, La		24	do	
		Elleslie, Miss		20	do	
		Upper Delta to Bedford, La		23	do	
		Glenora to Longwood, Miss		20	do	
10	McGavock & Tate	Green s to Fairview		35	do	
		Lake Concordia Breaks		30	do	
		Hole in the Wall and Waterproof Gaps		35	do	
		Hardscrabble and Bondurant		34	do	
		Upper Delta to Bedford		36	do	
		Sparta, above Duckport		30	do	
		Milliken's Bend to Cabin Teele		30	do	
		Omega to Milliken's Bend		30	do	
		Raleigh to Willow Point		30	do	
		Wilton to Raleigh		32	do	
		Elleslie		27	do	
		Longwood		27	do	
		Riverton Break		32	do	
		Parker's Enlargement and Breaks		32	do	
11	M. Crowley, Saint Louis, Mo	Longwood	86, 000	27	$80 per acre	
12	David Mayer, Vicksburg, Miss	Chotard		22		
	John D. Tinney, Vicksburg, Miss	Magna Vista to Chotard		22	$30 per acre	
		Shiloh to Tennessee		21	do	
		Skipwith's		23	do	
		Longwood		22	do	
		Sparta		21	do	
		Wilton to Raleigh		23	do	
		Raleigh to Willow Point		22		
13	John B. Reid, Vicksburg, Miss	Upper Delta to Bedfords		25⅞	$75 per acre	
14	T. C. Bedford, Vicksburg, Miss	Castleman's to Buck Ridge		33½	$100 per acre	
15	John B. Reid, Vicksburg, Miss	Omega to Milliken's Bend		22	$75 per acre	
		Milliken's Bend to Cabin Teele		19	do	
		Raleigh to Willow Point		23½	do	
		Ashton to Lake Providence		22	do	
16	George Foster, Villa Vista, La	Raleigh to Willow Point		24½	do	
17	P. J. Kennedy, New Orleans, La	Wilton to Raleigh	390, 000	25¾		
		Raleigh to Willow Point	50, 000	24½		Includes clearing and grubbing.
		Omega to Milliken's Bend	190, 000	25¼		
		Milliken's Bend to Cabin Teele	96, 000	24¼		

18	P. J. Kennedy, New Orleans, La	From Atchafalaya to Red River Landing.	122,000	36		
		Raccourci Crevasses	84,000	30	.....	Includes clearing and grubbing.
		Morganza and Stewart Crevasses	175,000	40		
		Point Coupee Crevasses	120,000	36		
19	Tom. O'Hara and Jno. J. Cooney, Memphis, Tenn.	Elleslie Levee	.....	23	Heavy clearing and grubbing $48 per acre, light clearing and grubbing $36 per acre.	
20	Wirt Adams, President Mississippi Contract and Improvement Company, Jackson, Miss.	Chotard's	.....	21½	.....do	
		Magna Vista to Chotard's	.....	23	.....do	
		Shiloh to Tennessee	.....	24	.....do	
		Elleslie	.....	21	.....do	
		Skipwith	.....	24	.....do	
		Longwood	.....	21	.....do	
		Jenkins to Easton	.....	23½	..... do	
		Clay and Baggott to Roland's	.....	23	.....do	
		Wade Break	.....	23½	.....do	
		Hughes Break	.....	23	.....do	
		Beulah to Hughes	.....	24	.....do	
		Beulah Enlargement and Clear Creek Break.	.....	24	.....Jo	
		Beulah Breaks, 1 to 9	.....	23	.....do	
		Riverton Breaks	.....	24	.....do	
		Parkers Enlargement and Breaks	.....	23	.....do	
		Lake Charles Break	.....	22	.....do	
21	James Madden, Carthage, Ill	Elleslie Levee	.....	21½	.....	
22	James F. Stokes, Terrance, Miss	Riverton Break	.....	27	$1,000	
23	F. L. Maxwell, Mound Madison Parish, La.	Sparta Levee	.....	19⅔	.....	
24	Luke Madden, Delta, La	Upper Delta to Bedford	.....	23½	.....	
		Sparta to Duckport	.....	18½	.....	
25	C. L. Hardeman, New Orleans, La	Raccourci Crevasse	84,000	24	.....	
26	G. C. Goldman, Waterpooof, La	Hole in the Wall and Waterproof Gaps	.....	31½	.....	
		Kemp Extension	.....	42	$95 per acre	
27	Robert McNamara, New Orleans, La	Hole in the Wall and Waterproof Gaps	38,000	26	.....	
		Milliken's Bend to Cabin Teele	96,000	26	.....	
		Raleigh to Willow Point	50,000	26	.....	
28	N. W. Irish	From Atchafalaya River to Red River Landing.	.....	26	.....	
		Hog Point to Raccourci	.....	26	.....	
		Raccourci Crevasses	.....	26	.....	
29	John Kiernan, Natchez, Miss.; Michael Phelan, Natchez, Miss.	Lake Concordia Breaks	301,000	18	No charge	
30	Peter Nelson, A. McKay, Oskaloosa, Iowa.	Magna Vista to Chotard's, Miss	70,000	40	Clearing and grubbing, $50 per acre.	All new levee work.
31	Jer. Fruin, Saint Louis, Mo	Wilton to Raleigh	.....	31	.....do	
	W. H. Swift, Saint Louis, Mo	Elleslie Levee	.....	24	.....do	
		Skipwith	.....	24	.....do	
		Longwood	.....	24	.....do	
		Clay and Bagott to Roland	.....	29	.....do	

6.—*Abstract of proposals for levee work received in response to the following advertisement, opened September* 25, 1882, *&c.*—Continued.

Number of proposals.	Names of bidders.	Localiy of levee.	Number of cubic yards.	Price per cubic yard.	Price of felling timber.	Remarks. (See also the abstract by localities, following, No. 8.) All proposals more or less informal.
		Wade Breaks		$0 24	Cleaning and grading, $50 per acre.	
		Hughes Breaks		24	do	
		Beulah to Hughes'		28	do	
		Beulah Enlargement and Clear Creek Break.		29	do	
		Beulah Breaks, 1 to 9		32	do	
		Riverton Breaks		24	do	
32	Gustavus A. Meyer, New Orleans, La	From Atchafalaya River to Red River Landing.	122, 000	22½		
		Morganzea and Stewart Crevasses	175, 000	24½		
		Point Coupee Crevasse	120, 000	25		
		Hardscrabble and Bondurant	330, 000	28		
		Ashton Crevasse, and Lake Providence Reach.	272, 000	27½		
33	G. Y. Scott, Rosedale, Miss	Beulah Enlargement to Riverton Junction.		33	$600, entire line	Embankment.
				33		Excavation.
	P. F. Lamb, Concordia, Miss	Breaks from 1 to 9		33	$400	Do.
		Do		28		Embankment.
		Hughes' Break		29	$200	Excavation.
		Do		26		Embankment.
34	James Baine, Waterproof, La	Closing Hole in the Wall and Waterproof Gaps.				
35	Chas. Bryan, Cabin Teel, La.; Chas. Colthorpe, Cabin Teel, La.	Milliken's Bend and Cabin Teele, La	96, 000	22		
36	Thos. O'Malley, Donaldsonville, La	Raccourci Crevasses	84, 000	25	$25 per acre	
		Point Coupee Crevasse	120, 000	35	do	

I certify that the above abstract is correct.

AMOS STICKNEY,
Major of Engineers, U. S. A., President of Board.

7.– *Abstract of proposals for levee work, received in response to the following circular-letter dated September 28, 1882, and opened September 29, 1882, by the Board of Engineers, convened by Special Orders No. 88, Headquarters Corps of Engineers, dated Washington, D. C., August 29, 1882.*

Mr. ——— ———,
———— ———,

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., September 28, 1882.

SIR: The Board of Engineers having rejected all bids received on certain named levees, invite you to make proposals on such as you may wish. The proposals to be handed into this office by 4 p. m., September 29, 1882. The levees are as follows, viz:

	Cubic yards.
LOUISIANA.	
Kemp's Breaks and extension, about	340,000
Shipp's Bayou to Hard Times, about	183,000
Between Castleman's and Buck Ridge, near Point Pleasant, about	30,000
MISSISSIPPI.	
Jenkins to Easton, about	84,000
Shiloh to Tennessee, about	70,000
Roland's to Jenkins, about	175,000

Yours, respectfully,

AMOS STICKNEY,
Major of Engineers, U. S. A.

Number of proposal.	Names of bidders.	Locality of levee.	Number of cubic yards.	Price per cubic yard.	Price of felling timber.	Remarks. (See also the abstract, by localities, following No. 8.) All proposals more or less informal.
1	P. F. Lamb	Shiloh to Tennessee		$0 29	$75 per acre	
		Roland's to Jenkins		31	do	
2	R. K. Stansul & Co	Kemp's break and extension		37	55 per acre	Embankment.
		Shipp's Bayou to Hard Times		33⅓	do	Excavation 30 cents.
		Between Castleman's and Buck Ridge, near Point Pleasant.		33	do	Do.
		Jenkins to Easton		37	do	Do.
		Shiloh to Tennessee		33	do	Do.
		Roland to Jenkins		31	do	Do.
3	McGavock & Tate, Memphis, Tenn	Kemp's breaks and extension		34½	do	
		Shipp's Bayou to Hard Times		34½	do	
		Between Castleman's and Buck Ridge, near Point Pleasant.		34½		
		Jenkins to Easton		28		
		Shiloh to Tennessee		29		
		Roland's to Jenkins		30		
	John B. Reid	Kemp's breaks and extension				
		Shipp's Bayou to Hard Times		31	$100 per acre	
		Between Castleman's and Buck Ridge, near Point Pleasant.		23	$60 per acre	

7.—*Abstract of proposals for levee work received in response to the following circular-letter dated September* 25, 1882, *&c.*—Continued.

Number of proposal.	Names of bidders.	Locality of levee.	Number of cubic yards.	Price per cubic yard.	Price of felling timber.	Remarks. (See also the abstract, by localities, following No. 8.) All proposals more or less informal.
5	Arnold & Co	Shipp's Bayou to Hard Times		32¾	$50 per acre	
		Between Castleman's and Buck Ridge near Point Pleasant.		26	do	
		Jenkins to Easton's breaks and enlargement.		28	do	
		Shilo to Tennesse		24¾	do	
		Enlargement and breaks				
6	P. G. Meath	Shipp's Bayou to Hard Times	183, 000	28	$40 per acre	Embankment.
				20		Muck-ditch, drain and sipe-ditches.
				25		Protection levees.
7	J. L. Perkins	Roland's levee to Jenkins.		29	$50 per acre	Embankment.
				27		Excavation.
8	M. W. Hughes, Vicksburg, Miss	Kemp's breaks and extension		30	$65 per acre	
	J. B. McGinty, New Orleans, La	Shipp's Bayou to Hard Times		30	do	
		Between Castleman's and Buck Ridge, near Point Pleasant.		26½		
9	Green Clay, Bolivar, Miss	Roland's to Jenkins		28½	$1, 000	
		Jenkins to Easton		26½	$300	
	E. F. Miller, Bolivar, Miss					
10	P. J. Kennedy, New Orleans, La	Kemp's breaks and extension	340, 000	28½	$35 per acre	
		Shipp's Bayou to Hard Times	183, 000	28½	do	
		Between Castleman's and Buck Ridge, Point Pleasant.	30, 000	23	do	
11	G. A. Meyer, New Orleans, La	Kemp's extension	280, 000	28	(Left to engineer in charge.)	
12	John B. Reid, Vicksburg, Miss	Kemp's levee, breaks, and extension		33¾	$85 per acre	Embankment.
	George Arnold, Memphis, Tenn			33¾		Excavation.
13	James Madden, Carthage, Ill	Between Castleman's and Buck Ridge, near Point Pleasant.		20	$60 per acre	
		Jenkins to Easton		24¾	do	
14	Fruin & Co., Saint Louis, Mo	Kemp's break and extension		37	do	
		Shipp's Bayou to Hard Times		37	do	
		Jenkins to Easton		30	do	
		Shiloh to Tennessee		29	do	
		Roland to Jenkins		30	do	

I certify that the above abstract is correct.

AMOS STICKNEY,
Major of Engineers, U. S. A.,
President of Board.

8.—*Abstract by localities, with recommendations.*

ATCHAFALAYA RIVER TO RED RIVER LANDING.

FIRST LETTING.

P. J. Kennedy (include clearing and grubbing)	$0 36
N. W. Irish	26
G. A. Meyer	22½

REMARKS.—Recommended that contract be awarded to G. A. Meyer, the lowest bidder.

HOG POINT TO RACCOURCI.

FIRST LETTING.

N. W. Irish	$0 26

REMARKS.—Recommended that contract be awarded to N. W. Irish, the lowest bidder.

RACCOURCI CREVASSES.

FIRST LETTING.

P. J. Kennedy (including clearing and grubbing)	$0 30
C. L. Hardeman	24
N. W. Irish	26
O'Malley	25

REMARKS.—Recommended that contract be awarded to C. L. Hardeman, the lowest bidder.

MORGANZA AND STEWART CREVASSES.

FIRST LETTING.

P. J. Kennedy (including clearing and grubbing)	$0 40
G. A. Meyer	24½

REMARKS.—Recommended that contract be awarded to G. A. Meyer, the lowest bidder.

POINT COUPÉE CREVASSE.

FIRST LETTING.

P. J. Kennedy (including clearing and grubbing)	$0 36
G. A. Meyer	25
O'Malley	35

REMARKS.—Recommended that contract be awarded to G. A. Meyer, the lowest bidder.

BOUGIERE CREVASSE.

FIRST LETTING.

R. G. Huston & Co	$0 35

REMARKS.—Recommended that all bids be rejected, for the reason that it was found inadvisable to close this break, the funds not being sufficient.

GREEN'S TO FAIRVIEW.

FIRST LETTING.

Huston & Co	$0 28
McGavock & Tate	35

REMARKS.—Recommended that contract be awarded to Huston & Co., the lowest bidders.

LAKE CONCORDIA BREAKS.

FIRST LETTING.

Huston & Co	$0 27
Hughes & McGinty	21
McGavock & Tate	30
Kiernan & Phelan	18

REMARKS.—Recommended that contract be awarded to Kiernan & Phelan, the lowest bidders.

Hole in the Wall and Waterproof Gaps.

FIRST LETTING.

Huston & Co	$0 27
McGavock & Tate	35
G. C. Goldman	31½
R. McNamara	26

Remarks.—All bids rejected for the reason that the State engineer of Louisiana offered to close these gaps.

Kempe Extension.

FIRST LETTING.

Huston & Co	$0 38
G. C. Goldman	42

Remarks.—All bids rejected, being considered too high.

SECOND LETTING.

R. L. Stansell & Co.:	
Embankment	$0 37
Excavation	30
McGavock & Tate	34½
Hughes & McGinty	30
P. J. Kennedy	28½
G. A. Meyer	28
Arnold & Reid	33¾
Fruin & Co	37

Remarks.—Recommended that contract be awarded to Kennedy, Meyer having a full allowance of work in other localities.

Hardscrabble and Bondurant.

FIRST LETTING.

Huston & Co	$0 35
McGavock & Tate	34
G. A. Meyer	28

Remarks.—Recommended that the contract be awarded to G. A Meyer, the lowest bidder.

Shipp's Bayou to Hard Times.

FIRST LETTING.

Huston & Co	$0 34

Remarks.—All bids were rejected, being considered too high.

SECOND LETTING.

R. L. Stansell & Co.:	
Embankment	$0 33½
Excavation	30
McGavock & Tate	34½
John B. Reid	31
Arnold & Co	32¼
P. G. Meath	28
Hughes & McGinty	30
P. J. Kennedy	28½
Fruin & Co	37

Remarks.—Recommended that contract be awarded to P. G. Meath, his bid being the lowest.

Castleman's to Buck Ridge.

FIRST LETTING.

Huston & Co	$0 36
T. C. Bedford	33½

Remarks.—All bids rejected, being considered too high.

SECOND LETTING.

(Castleman's to Buck Bridge, near Point Pleasant.)

R. L. Stansell & Co.:	
Embankment	$0 33
Excavation	30
McGavock & Tate	34½
John B. Reid	23
Arnold & Co	26
Hughes & McGinty	26½
P. J. Kennedy	23
James Madden	20

REMARKS.—On second letting amount of cubic yards reduced to 30,000 on account of lack of funds. Recommended that contract be awarded to James Madden, his being the lowest bid.

UPPER DELTA TO BEDFORD.

FIRST LETTING.

Huston & Co	$0 29
Hughes & McGinty	24
Hugh Carlisle	23
McGavock & Tate	36
J. B. Reid	25⅞
Luke Madden	23½

REMARKS.—Recommended that contract be awarded to Hugh Carlisle, the lowest bidder.

SPARTA, ABOVE DUCKPORT.

FIRST LETTING.

Huston & Co	$0 25
Hugh Carlisle	20
McGavock & Tate	30
Mayer & Co	21
F. L. Maxwell	19¾
Luke Madden	18½

REMARKS.—Recommended that contract be awarded to Luke Madden, the lowest bidder.

MILLIKEN'S BEND TO CABIN TEELE.

FIRST LETTING.

Huston & Co	$0 25
Hughes & McGinty	21
Hugh Carlisle	20
McGavock & Tate	30
J. B. Reid	19
P. J. Kennedy (including clearing and grubbing)	24¼
R. McNamara	26
Bryan & Colthorp	22

REMARKS.—Recommended that contract be awarded to J. B. Reid, the lowest bidder.

OMEGA TO MILLIKEN'S BEND.

FIRST LETTING.

Hugh Carlisle	$0 21
McGavock & Tate	30
J. B. Reid	22
P. J. Kennedy (including clearing and grubbing)	25¼

REMARKS.—Recommended that contract be awarded to Hugh Carlisle, being the lowest bidder.

RALEIGH TO WILLOW POINT.

FIRST LETTING.

Huston & Co	$0 24
Hugh Carlisle	24
McGavock & Tate	30
Mayer & Co	22

J. B. Reid	$0 23½
George Foster	24½
P. J. Kennedy (including clearing and grubbing)	24½
R. McNamara	26

REMARKS.—Recommended that contract be awarded to Mayer & Co., being the lowest bidder.

WILTON TO RALEIGH.

FIRST LETTING.

Huston & Co	$0 24
Hugh Carlisle	24
McGavock & Tate	32
Mayer & Co	23
P. J. Kennedy (including clearing and grubbing)	25¾
Fruin & Co	31

REMARKS.—Recommended to award contract to Huston & Co., Carlisle having his full allowance in other localities. Mayer & Co. not being considered reliable for such an amount of work.

ASHTON CREVASSE AND LAKE PROVIDENCE REACH.

FIRST LETTING.

Huston & Co	$0 35
J. B. Reid	22
G. A. Meyer	27½

REMARKS.—Recommended that contract be awarded to J. B. Reid, being the lowest bidder.

CHOTARD'S.

FIRST LETTING.

Arnold & De Garris	$0 24
Huston & Co	36
Mayer & Co	22
Wirt Adams, President M. C. and I. Co	21½

REMARKS.—All bids rejected, it being found inadvisable to construct this levee, for want of funds.

MAGNA VISTA TO CHOTARDS.

FIRST LETTING.

Arnold & De Garris	$0 23
Huston & Co	36
Mayer & Co	22
Wirt Adams, president M. C. & I. Co	23
Nelson & McKay	40

REMARKS.—Recommended that contract be awarded to Mayer & Co., being the lowest bidders.

SHILOH TO TENNESSEE.

FIRST LETTING.

Huston & Co	$0 34
Mayer & Co	21
Wirt Adams, president M. C. & I. Co	24

REMARKS.—All bids rejected; the lowest bidders, Mayer & Co., not being considered reliable for such an amount of work in connection with their other work. Wirt Adams rejected on account of convict labor. Other bid too high.

SECOND LETTING.

P. F. Lamb	$0 29
R. L. Stansell & Co:	
Embankment	33
Excavation	30
McGavock & Tate	29
Arnold & Co	24¾
Fruin & Co	29

REMARKS.—Recommend that contract be awarded to Arnold & Co., their bid being the lowest.

ELLESLIE.

FIRST LETTING.

Arnold & De Garris	$0 21
Huston & Co	28
Hugh Carlisle	20
McGavock & Tate	27
O'Hara & Cooney	23
Wirt Adams, president M. C. & I. Co	21
James Madden	21½
Fruin & Co	24

REMARKS.—Recommended that contract be awarded to Hugh Carlisle, being the lowest bidder.

SKIPWITH.

FIRST LETTING.

W. B. Strang & Co.:	
New levee	$0 18
Repairing old levee	19½
Huston & Co	28
Mayer & Co	23
Wirt Adams, president M. C. & I. Co	24
Fruin & Co	24

REMARKS.—Recommended that contract be awarded to W. B. Strang & Co., being the lowest bidders.

LONGWOOD.

FIRST LETTING.

W. B. Strang & Co.:	
New levee	$0 18
Repairing old levee	19½
T. C. Hicks:	
Excavation	23
Embankment	24½
Huston & Co	26
Hugh Carlisle	20
McGavock & Tate	27
M. Crowley	27
Mayer & Co	22
Wirt Adams, president M. C. & I. Co	21
Fruin & Co	24

REMARKS.—Recommended that contract be awarded to W. B. Strang & Co., being the lowest bidders.

JENKINS TO EASTON.

FIRST LETTING.

Huston & Co	$0 35
Wirt Adams, president M. C. & I. Co	23½

REMARKS.—Wirt Adams rejected on account of convict labor. Other bid rejected, being considered too high.

SECOND LETTING.

R. L. Stansell & Co.:	
Embankment	$0 37
Excavation	30
McGavock & Tate	28
Arnold & Co	28
Clay & Miller	26½
James Madden	24¾
Fruin & Co	30

REMARKS.—Recommended that contract be awarded to James Madden, his being the lowest bid.

CLAY AND BAGOTT TO ROLAND'S.

FIRST LETTING.

Huston & Co	$0 35
Miller & Clay	34
Wirt Adams, president M. C. & I. Co	23
Fruin & Co	29

REMARKS.—Recommended that contract be awarded to Fruin & Co., Wirt Adams having declined on account of decision forbidding employment of convict labor.

WADE BREAK.

FIRST LETTING.

Huston & Co	$0 35
Miller & Clay	26
Wirt Adams, president M. C. & I. Co	23½
Fruin & Co	24

REMARKS.—Recommended that contract be awarded to Fruin & Co., Wirt Adams having declined on account of decision forbidding employment of convict labor.

HUGHES'S BREAK.

FIRST LETTING.

Huston & Co	$0 33
Wirt Adams, president M. C. & I. Co	23
Fruin & Co	24
Scott & Lamb:	
Embankment	26
Excavation	29

REMARKS.—Recommended that contract be awarded to Fruin & Co., Wirt Adams having declined on account of decision forbidding employment of convict labor.

BEULAH TO HUGHES.

FIRST LETTING.

Huston & Co	$0 35
Wirt Adams, president M. C. & I. Co	24
Fruin & Co	28

REMARKS. —Recommended that contract be awarded to Fruin & Co., Wirt Adams having declined on account of decision forbidding employment of convict labor.

BEULAH ENLARGEMENT AND CLEAR-CREEK BREAK.

FIRST LETTING.

Huston & Co	$0 36
Wirt Adams, president M. C. & I. Co	24
Fruin & Co	29
Scott & Lamb	33

REMARKS.—Recommended that contract be awarded to Fruin & Co., Wirt Adams having declined on account of decision forbidding employment of convict labor.

BEULAH BREAKS, 1 TO 9.

FIRST LETTING.

Wirt Adams, president M. C. & I. Co	$0 23
Fruin & Co	32
Scott & Lamb:	
Embankment	28
Excavation	33

REMARKS.—Recommended that contract be awarded to Scott & Lamb, Wirt Adams having declined on account of decision forbidding employment of convict labor.

RIVERTON BREAK.

FIRST LETTING.

W. B. Strang & Co:	
New levee	$0 18
Repairing old levee	19½
Huston & Co	38
McGavock & Tate	32
Wirt Adams, president M. C. & I. Co	24
J. F. Stokes	27
Fruin & Co	24

REMARKS.—Recommended that contract be awared to W. B. Strang & Co., being the lowest bidders.

PARKER'S ENLARGEMENT AND BREAKS.

FIRST LETTING.

Huston & Co	$0 37
McGavock & Tate	32
Wirt Adams, president M. C. & I. Co	23

REMARKS.—Recommended that contract be awarded to McGavock & Tate, Wirt Adams having declined on account of the decision refusing employment of convict labor.

LAKE CHARLES BREAK.

FIRST LETTING.

J. W. Eldridge:	
Excavation	$0 30
Embankment	25
Wirt Adams, president M. C. & I. Co	22

REMARKS.—Recommend that contract be awarded to J. W. Eldridge, Wirt Adams having declined on account of decision refusing employment of convict labor.

ROLAND'S TO JENKINS.

SECOND LETTING.

P. F. Lamb	$0 31
R. L. Stansell & Co:	
Embankment	31
Excavation	30
McGavock & Tate	30
J. L. Perkins:	
Embankment	29
Excavation	27
Clay & Miller	28½
Fruin & Co	30

REMARKS.—This was unintentionally left out in first letting. Recommended that contract be awarded to Clay & Miller, being the lowest bidders.

9.—*Abstract of proposals for levee work received in response to the following advertisement, dated September* 30, 1882, *and opened October* 16, 1882, *by the Board of Engineers, convened by Special Orders No.* 88, *Headquarters Corps of Engineers, dated Washington, D. C., August* 29, 1882:

PROPOSALS.

LEVEE WORK.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., September 30, 1882.

Sealed proposals in duplicate will be received till 12 o'clock noon, October 16, 1882, at United States Engineer Office at Memphis, Tenn., for construction or repair of levees on Mississippi River in the States of Arkansas and Mississippi, as follows, viz:

ARKANSAS.

Duffin's Break, about 60,000 cubic yards.
Panther Forest, about 175,000 cubic yards.
Whisky Chute, about 80,000 cubic yards.

MISSISSIPPI.

Garth's Break to Jefferson's, inclusive, about 95,000 cubic yards.
Bland's Bayou to Garland's, inclusive, about 66,500 cubic yards.

Bidders must furnish a bond of twenty-five per cent. of the amount of their bids, that they will enter into contract within five days of notification of award of contract. Contractors must furnish a similar bond for execution of contract. Work must be commenced within ten days of award of contract, and be completed by March 1, 1883.

Blank forms, instructions to bidders, and information respecting localities and character of work may be obtained by addressing United States Engineer Office, Memphis, Tenn. Proposals must be made on forms furnished. The United States reserves the right to reject any or all bids.

Proposals must be addressed to Maj. Amos Stickney, president Board of Engineers, United States Engineer Office, Memphis, Tenn., and marked on outside of envelope "Proposals for levee work."

Numbers of proposals.	Names of bidders.	Locality of levees.	Price per cubic yard.	Price of felling timber.	Remarks (see also the abstract by localities following, No. 10). All proposals more or less informal.
				Per acre.	
1	Patrick Francis Lamb, Bolivar County, Mississippi.	Bland's Bayou to Garland	$0.25½	$75	Embankment.
		Do	28	75	Excavation.
		Duffin's Break	28	75	Do.
		Do	27½	75	Embankment.
2	W. M. Forrest and J. T. Stanton, Memphis, Tenn.	Garth's Break to Jefferson	22½	50	For Jefferson Break.
			27½	50	For Beard Levee.
			24½	50	For McCloud Break.
3	Arnold & Co., Memphis, Tenn.	Duffin's Break	24¾	75	
		Panther Forest	26¾	75	
		Garth's Break to Jefferson	23¾	75	
		Bland's Bayou to Garland	24¾	75	
4	McGavock & Tate, Colorado.	Garth's Break to Jefferson	28	40	
		Bland's Bayou to Garland	28	40	
5	Andrew Bodkin, Memphis, Tenn.	Garth's Break to Jefferson	25	40	
		Bland's Bayou to Garland	25	40	
6	F. Gillooley and John Clancey, Memphis, Tenn.	Garth's Break to Jefferson	24¾	45	
7	P. M. Winters and John Walsh, Memphis, Tenn.	Duffin's Break	24¾	40	
8	William B. Street and Robert E. Craig, Luna Landing, Ark.	Panther Forest	25	70	From Gaines' Landing to Luna Landing, on the front or indirect line.
9	Luther F. Warder, Jeffersonville, Ind.	Duffin's Break	28	30	
		Panther Forest	28	30	
10	Timothy Sullivan, Doniphan, Mo.	Garth's Break to Jefferson	22	75	

I certify that the above abstract is correct.

AMOS STICKNEY,
Major of Engineers, U. S. A., President of Board.

10.—*Abstract by localities and recommendations.* (*See No.* 9.)

DUFFIN BREAK.

P. F. Lamb:
- Excavation $0 28
- Embankment 27½

Arnold & Co 24¾
P. M. Winters and John Walsh 24¾
L. F. Warder 28

REMARKS.—Recommended that contract be awarded to Winters & Walsh, their bid being the lowest.

PANTHER FOREST.

Arnold & Co	$0 26¾
W. B. Street and R. E. Craig	25
L. F. Warder	28

REMARKS.—Recommended that contract be awarded to Street & Craig, they being the lowest bidders.

BLAND'S BAYOU TO GARLAND'S.

P. F. Lamb:	
Embankment	$0 25½
Excavation	28
Arnold & Co	24¾
McGavock & Tate	28
Andrew Bodkin	25

REMARKS.—Recommended that contract be awarded to Arnold & Co., theirs being the lowest bid.

GARTH'S BREAK TO JEFFERSON.

Forrest & Stanton:	
Jefferson breaks	$0 22½
Beard levee breaks	27½
McCloud levee breaks	24½
Arnold & Co	23¾
McGavock & Tate	28
Andrew Bodkin	25
F. Gillooly and John Clancey	24¾
Timothy Sullivan	22

REMARKS.—Recommended that contract be awarded to Timothy Sullivan, his being the lowest bid.

WHISKY CHUTE.

No bids were received. Owing to the fact that recent surveys have developed an increased quantity of earthwork in other levees, it was decided by the Board to do nothing at this point.

11.—*Specifications for levee work on Mississippi River.*

Work under these specifications will include all excavations and embankments required for the formation of the levee; cutting all ditches or drains about or contiguous to the levee; the excavations and embankments necessary for reconstructing public roads and passways, in cases where they are destroyed or interfered with by the construction of the levee, and all other excavations and embankments connected with or incident to the construction of the levee; the grubbing and clearing of all timber and other vegetable matter within the levee way; and the felling of all trees within 100 feet of the center line of the levee.

All cuttings, other than borrowing for embankment, shall be measured in excavation and estimated by the cubic yard and paid for as earth.

The levee will be graded 8 feet wide on top, except where otherwise directed by the engineer, with side slopes of such inclination as the engineer in each case shall designate, and in conformity to such heights of filling as may have been or may hereafter be determined upon by the engineer. Material for the levee shall not be procured within a less distauce from the front slope stakes than 20 feet.

The ground to be occupied by the levee must first be cleared of trees, stumps, logs, trash, weeds, and all perishable matter, the trees and stumps being cut level with the surface of the ground; when the levee is less than 5 feet high all stumps shall be grubbed out by the roots. The entire surface must then be thoroughly broken with a spade or plow, in order to form a bond with the earth deposited. Then a muck ditch must be cut 4 feet wide at top and 2 feet at bottom and 3 feet deep; all stumps and roots crossing it being carefully taken out and removed beyond the base of the levee. The muck ditch must be cut 3 feet from the center line of the levee on that side next to the river (great care being taken not to displace any of the stakes of the center line). As each section of a mile in length, or the entire levee is thus cleared, broken, and muck ditch cut, the contractor must notify the engineer of the fact, when he will measure the contents of the ditch, and the area of the surface broken, and then set stakes each side of the center, at the proper distance, for the base of the levee. But in no case will the stakes be set till the clearing, surface breaking, and muck ditch are done as above described, one-fifth of a mile in advance of the embankment, and no embankment put up without this previous preparation, or before the side stakes

are set, will be estimated or paid for. As soon as the work is staked, the muck ditch must be filled in again, with buckshot earth or clay obtained from without the base of the levee, and the earth tamped in by horses or mules, ridden rapidly back and forward constantly while the earth is being put in, or by tamping mauls; at least one horse to every ten wheelbarrows being thus employed, or one tamping maul to six barrows. This filling and tamping to be kept one-fourth mile in advance of the embankment. In case of repair of old levee, all stumps, logs, and trees, where they are known to exist, must be dug out, and the muck ditch cut near the outside base of old levee, unless the engineer in charge shall ascertain it to be unnecessary from its previous mode of construction. The surface of all old levees must be well broken. All existing levees, or parts of old levee, must be left, except by special permission of the engineer in charge. Openings shall be cut through the old levee, as may be required by the engineer in charge, at least as deep as the natural surface, to allow the rising water gradual access to the new levee.

When the ground is prepared as required, the embankment will be commenced, and a sufficient number of dumping men be kept on the levee to spread the earth as it is wheeled or carted in. The slopes shall in every case be commenced FULL OUT TO THE SIDE STAKES, and carried regularly up as the embankment progresses. The engineer in setting the center stakes will mark on them the height to true grade, but the contractor must build the embankment one-fifth higher than the height marked on the stakes (unless otherwise directed by the engineer), for shrinkage or settling; this allowance of one-fifth being so disposed on the top and slopes as to give the required width at top of settling, and to fill out the slopes so as to make one plane from edge of crown to base of levee. Nothing will be paid for settling or shrinkage, but the levee will be paid for as estimated up to true grade. As each continuous quarter-mile is thus finished, the contractor must notify the engineer in charge. If the levee be found deficient in height, slopes, or base, or not to have the full settling on the top and slopes, the contractor must go over it immediately and correct all deficiencies.

In procuring material for the levee, the place will be designated by the engineer (always on the river side unless otherwise directed), and in excavating and removing it care must be taken to injure or disfigure the land as little as possible. In no case must it be obtained within twenty feet of the base of the levee on the river side, and the slope of the pit next to the embankment must not be less than one to one. If from unavoidable causes it becomes necessary to procure material on the land side of the levee, it must not be taken within forty feet of the base. But it is not to be taken from the land side at all, unless upon the written order of the engineer designating the place. Any encroachment upon the limits of either side must be measured by the engineer and deducted from the amount of the final estimate. At intervals of 100 feet bermes must be left across the borrow pits to prevent the flow of a current along the levee. In procuring material for the embankment, if the place designated by the engineer exceed 300 feet from the center line of the levee, one cent per cubic yard will be paid in addition to the contract price for every 100 feet of average haul exceeding 300 feet that said material may be transported. All levees shall be estimated in embankment, and not in excavation, and be paid by the cubic yard.

All earth designed for embankment must be entirely divested of roots, trash, and other perishable matter before being put in place.

The contractor shall plant the entire surface of the completed levee with living tufts of Bermuda sod 4 inches square, not more than 2 feet apart, and to the satisfaction of the engineer in charge.

In cutting drains, sipe ditches, or new channels for streams, they shall be cut at such distance from the levee as the engineer in charge may require; the material deposited in the adjacent embankment and paid for as specified in these specifications.

Whenever the route of the levee is traversed by public or private roads, commodious passing-places must be kept in safe condition for use; and in passing through farms the contractor must also keep up such temporary fences as may be necessary for the preservation of the crops and protection of property.

In anticipation of destructive floods during the progress of the work, the engineer may require a protection of timber work to be constructed around the ends of the levee and also a temporary protection levee to be built in front of the work upon such location as he may designate, and of such dimensions as he may direct. The engineer may also require the base of the levee to be covered with a mattress whenever necessary to protect the embankment, for which an extra compensation, to be determined in each case, will be made.

All damage or injury to the work resulting from flood or other cause shall be sustained by the contractor till finished and received by the engineer; and no work shall be received until fully and completely finished in accordance with the above specifications.

The price per cubic yard for levee is understood to cover all work under these specifications, except felling timber, for which a separate price for the whole of each advertised piece of work bid upon should be stated.

The above specifications, if not understood, will be fully explained by the engineer; but if willfully neglected no measurement or estimate will be made on the work until they are complied with.

Payments will be made monthly, reserving 10 per cent. till completion of contract.

The United States reserves the right to limit the work allotted to any one party to 500,000 cubic yards as a maximum; also, to increase or diminish the amounts advertised, which are approximate, to the extent that more detailed surveys, definite locations, and closer estimates may make necessary or advantageous for the work.

APPENDIX S.

A PAPER BY HENRY MITCHELL, MEMBER OF THE COMMISSION, ON THE OFFICE OF LEVEES AS AN ADJUNCT TO THE PLAN OF RIVER IMPROVEMENT.

The portion of the Mississippi River below Bayou Sara is free from channel obstructions for 275 miles and may be navigated by ships of great draught. Above Red River the crossings become shallow, and at a number of points bars occur which limit the draught of boats to less than ten feet in the low-water season.

The whole length of the river from Cairo to the Gulf presents a succession of turns or winds more or less acute, and after each turn a "crossing," so called because here the sailing course crosses from near one bank to near the other. The bends or turns present usually good depths of water, while the crossings are more shallow. The river thus offers a succession of pools and bars answering to bends and crossings.

There are 111 decided bends between Cairo and Red River as furnished by a superficial view, and closer inspection, by the aid of hydrographic charts, increases greatly this number. The number of decided crossings is about 175, but these crossings, while generally shallow, are comparatively few of them obstructions to low-water navigation at present. There are perhaps not more than 36 crossings below Cairo which offer obstructions at low-water to vessels drawing 10 feet, and the average depth in any reach which includes one pool and one crossing is greater than navigation demands; so that whatever means may be resorted to for deepening the water over the bar, there will be no direct injury to navigation from lowering the surface of the water in the pools.

ORIGIN OF BARS.

The river presents in effect a series of reverse curves with intermediate nodes. In floods it is a deep and rapid stream, and when compelled to go round a bend it scours away the concave bank and adjacent bed; but in this work it so exhausts its *vis viva* that it arrives at the reversion point wholly disabled from carrying further its load of earth. Here it throws down its burden, rises and wells over the banks into the adjacent swamps, if the volume of discharge be unusually great. Were the river not subject to floods a longitudinal profile along the channel-way would still show a mound at the crossing, because at the reversion point the more symmetrical section would pass the discharge with less maximum depth.

The greater width that we observe at the crossings of the Mississippi River seem to be due to the floods which bring such masses of earth that at the reversion points the river is choked and bursts its bounds; it widens because a less force is required to tumble down the unstable banks than to push further forward the load brought from the bend above.

The bars are not permanent in position; on the contrary, they are prone to shift as the bends become more acute, extend, or move downward. Indeed, under the general rule that the bars form at the reversion points of curves it is evident that their positions must vary as these curves vary, and that the holding of the curves by revetment or otherwise is an essential early step in the control of the river. It antedates logically the retrenchment which is to deepen the water at the bars.

It does not follow from the foregoing conclusions that the banks of the Mississippi River must be revetted through the entire distance from Cairo to Red River, some 800 miles, because, as we have seen, the crossings at which the obstructions at low water now occur are comparatively few and are prone to group themselves in certain reaches, the most conspicuous of which are those proposed for initial works in the report of the Commission. In each of these reaches, varying from 16 to 40 miles, the works of improvement may have to be made continuous before permanent benefit can be realized.

As far as we are now advised, the work required below Cairo should not involve more than 260 miles of full work, and it is hoped that much less will suffice.

One of the difficulties which presents itself in the work of regularization is the variance in direction of flow for low and high stages of the river, and this makes it

necessary in all plans to provide for the control of high as well as low river, and even to confine floods to the general tracks of lower stages.

The floods of the Lower Mississippi are not transient freshets, but long-continued elevations of the surface—so long continued that the trench maintained by the river represents not the mean, but more nearly the extreme, demand of the discharge. The height of the natural bank is independent of the total oscillation of the river, and is determined by the most permanent flood levels, precisely as the heights of banks of tidal creeks among salt marshes are determined by the height of mean high water to which they actually conform, whether the oscillation be three feet, as on the south coast of Massachusetts, or 60 feet, as in the Bay of Fundy.

From analogy we may infer that precisely as mean high-water corresponds to bank level, so does river bank level represent mean flood level, and as mean high-water is the average of all the recurrent high waters, including neaps as well as springs, so does mean flood, as represented by bank level, indicate the mean elevation of effective floods, including those which do not now reach bank level, as well as those which rise above it.

The obvious reason why, in the case of the tides, the banks represent high water is, that at this stage, or near it, the water remains longer than at any other, except low-water. The bank level of the river is, in the same way, the plane above and below which the flood heights oscillate.

We have taken the above mode of discussion, because we cannot distinguish in the case of the river all the rises as effective floods. If this inferential reasoning be admissible, we may conclude that *full river* and *mean high water* are synonymous terms; in other words, the capacity of the full river has been determined by the service it is called upon to perform in the flood season.

It is a mere truism to say that the river cannot raise its own banks to the extreme height it may itself reach, nor even to the height which it rarely reaches, because in flowing back to the falling river it must always undo some part of its constructive work. The rise of 1882, if at any point the highest on record, must be excluded from the mean, unless it is probable that an equally anomalous low flood season has left its traces in the river still.

Perhaps if the river did not continually alter its position, destroying on one side and building on the other, a higher grade of banks might be attained. Some old tracks of the river through the bottom lands, now left as lakes, are said to have bank levels in excess of those along the river in its new position. There is a considerable margin for incompleteness of the bank building to be considered in a general way for a shifting and overflowing river even if, as Mr. Ockerson observed, "the deposit will under ordinary circumstances keep pace with the caving, so that the bank will remain about the same height."

This limitation of the height of the bank to about the plane of ordinary high-water level is observed in all rivers molding their own beds, and in tidal creeks everywhere so far as we know, so that not only is it independent of the range of oscillation, and therefore independent of the position of the low-water plane, but it is also independent of the quality of alluvium. The foregoing would seem to limit the capacity of the river to the natural bank-full stage, however these banks may be artificially raised But it does not include the case where the top of the flood forsakes the main river course and escapes into the bottom to return many miles lower down; for here we have an intermediate reach deprived of the normal discharge. There are reaches in the Mississippi River where flood discharge has been lessened or has always been less, because of outlets above; these reaches can be at once improved by levees, preventing waste above them, because the ordinary flood level will be thus locally raised.

The Saint Francis and Yazoo bottoms rob the river of its legitimate discharge at one point to restore it at another, and these bottoms should be entirely closed except for the exit of their own drainage and that of other streams from their rear.

Anomalous floods have no permanent impress upon the average form and capacity of the river. This is patent and need not be discussed.

But the extreme rise of each season is an element in the *average;* we cannot, therefore, let it escape because it will reduce the average below this point. This would indicate that levees must then be high enough to restrain high floods.

We should now inquire if levees by increasing the flood discharge through any reach of the river should be expected to increase low-water depths?

Although the greater discharge induced by the levees during floods does not continue through the low-water season, a greater channel depth at the low-water should result, because a more acute form of cross-section appears. The cross-section profile reflects in its form the transverse curve of velocities, the apex of which is the thalweg of the stream. Scour is work increasing with the square of the velocities (above a certain initial) and the curve which represents it becomes more and more acute as velocities increase, so that the river at low-water finds itself at a lower absolute level but with an increased channel depth.

We have but to compare the Mississippi with many other rivers of less discharge in

the same manner, wandering among their own deposits, to confirm the view we have stated. The Mississippi is not only wider and deeper than these others in the average, but has actually more water upon its bars. Moreover, in the Mississippi River itself we discover the worst bars in front of the great "bottoms," where the river has lost its legitimate discharge by escape of floods.

Recalling the fact that the average depth of the Mississippi is more than ample, even along the fronts of the great bottoms, it might well be questioned whether the introduction of additional scouring volume on an extended scale would result in benefit if the levees perform no other office than the direct one which we have stated, especially as the levees cannot be made continuous because of the necessary provisions for lateral drains of great magnitude. But there is an indirect advantage in levees which is unequivocal.

When we consider that the slope of the river along its proper course averages scarcely one-third foot to the mile, while the bank slopes away from the river four to ten feet to the mile, it is easy to see to what an extent, during floods, the river is tempted to change its course. Even when the overflow is but a thin sheet compared with the great channel depth, the thread of motion of the main stream must be affected; and where the river is shallow a flood may and often does occur, with such depth of overflow as to turn the main direction of flow towards the banks, so as actually to slacken the flow along the channel beyond and suffer the latter to fill up, *for upon the surface slope and its direction the movements at all depths depend as expressed in the general formula.*

The most remarkable illustration of the effect of a crevasse to change the direction of the flow and to create a bar is offered by Cubitt's Gap, of which we have from repeated surveys a physical history. This outlet was originally artificial, but it has been so widened and deepened by the action of the currents that it is now a half-mile wide. At the river's brink this opening is very deep; but a short distance beyond it presents a sill with only eleven feet, and further on less than six feet of water upon it.

Mr. Henry L. Marindin, of the Coast and Geodetic Survey, in a report to the superintendent of that service, dated April 22, 1880, says: "A noticeable feature in front of the gap, and one which in great measure must be traced to it as its cause, is the formation of a flat on the west bank"—*i. e.*, of the main river, as shown by the deep contours, the 24 ft. curve more especially." *Thus we see that an escape of water over a waste weir six feet deep has turned the great river from its former course at four times that depth.*

We have shown that a bar must follow a turn in the river, because in making that turn the river is brought in conflict with its bank and exhausts its power. In this impact its slope beyond is really increased but with a diminution of velocity. In the same way and for the some reason, where a crevasse turns the stream somewhat upon its bank the bar must be expected below. The bar which Cubitt's Crevasse is causing and which is due not only to the loss of river volume but in some measure to the turn which it has induced, is so well discussed in the reports of Mr. Marindin and of Captain Heuer, United States Engineers, that we need only refer to those papers. They indicate very serious consequences to the maritime commerce of New Orleans if this bar building in the main river is to go on.

CONCLUSIONS.

The present river bank is usually at the grade of ordinary high river, but the river depths would be improved by a higher grade. The levee is a useful auxiliary to channel improvement even as now located, and if relocated with due regard to the special office of river improvement would be of decided benefit. The grade to which it should be raised is that required by floods, but provision against anomalous floods like that of 1882 is not necessary, unless under a question of economy.

In addition to the levees already prescribed, the Saint Francis bottom should be closed to the river floods as far as practicable with proper provision for drainage, outlets, &c.

HENRY MITCHELL.

BOSTON, *November* 1, 1882.

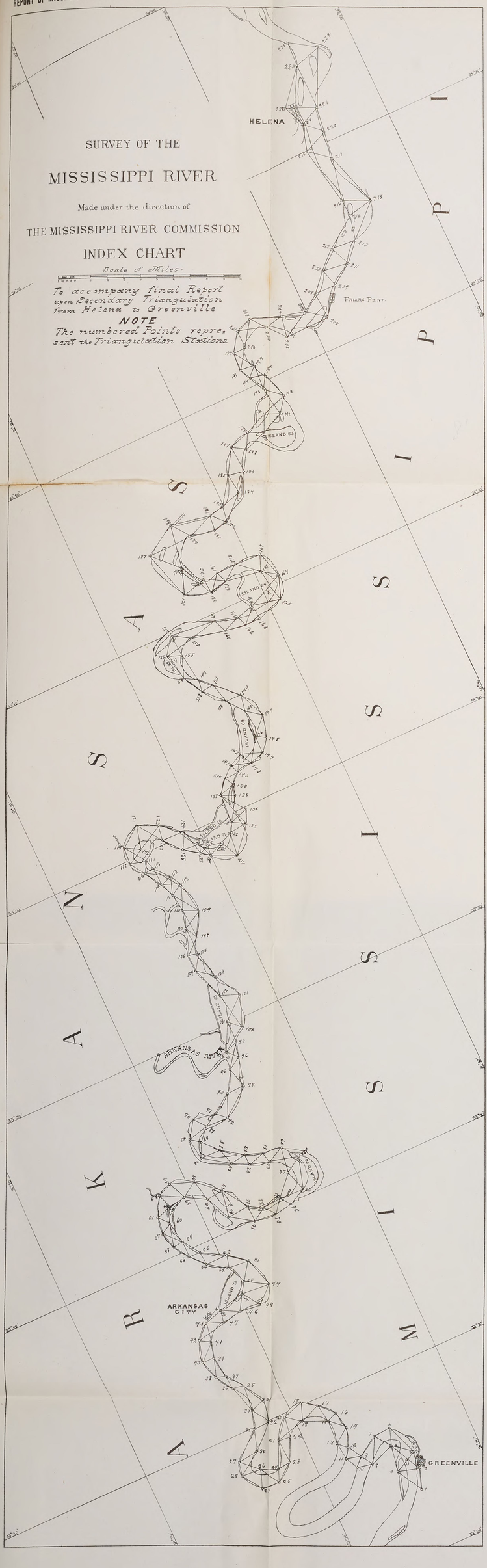

SURVEY OF THE
MISSISSIPPI RIVER
Made under the direction of
THE MISSISSIPPI RIVER COMMISSION
INDEX CHART
Scale of Miles:
To accompany final Report upon Secondary Triangulation from Helena to Greenville
NOTE
The numbered Points represent the Triangulation Stations.
HELENA
FRIARS POINT.
ISLAND 63
ISLAND 65
ISLAND 69
ISLAND 71
ISLAND 72
ISLAND 73
ISLAND 74
ARKANSAS RIVER
ARKANSAS CITY
GREENVILLE
MISSISSIPPI
ARKANSAS

PLATE No-I.

SKETCH

SHOWING CROSS SECTION LINES

AND

SPECIAL SECTIONS.

LOW WATER SURVEY NOV. 1879.

SCALE 2000 Ft = ONE INCH

2000 1000 0 2000 4000 6000

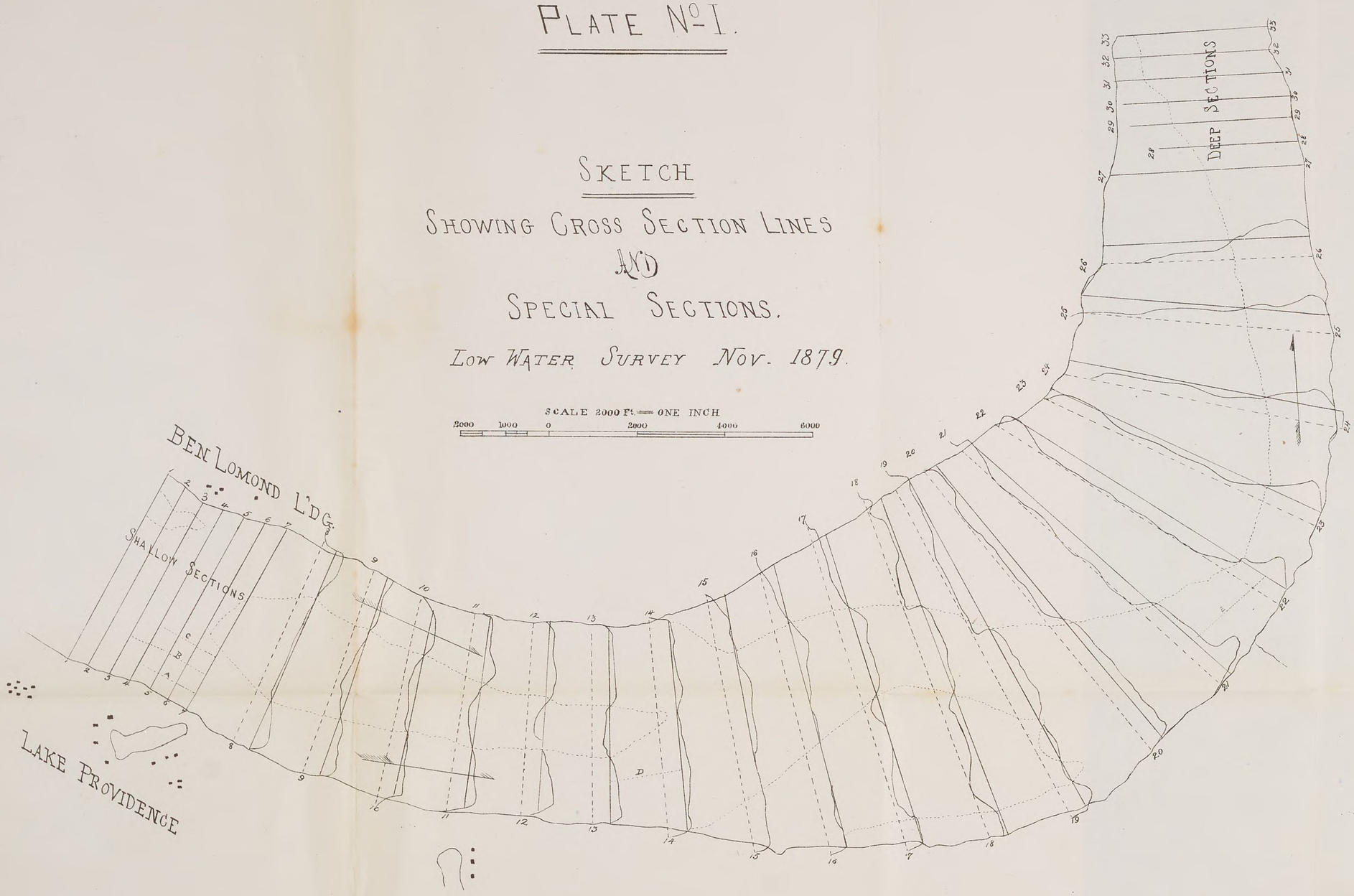
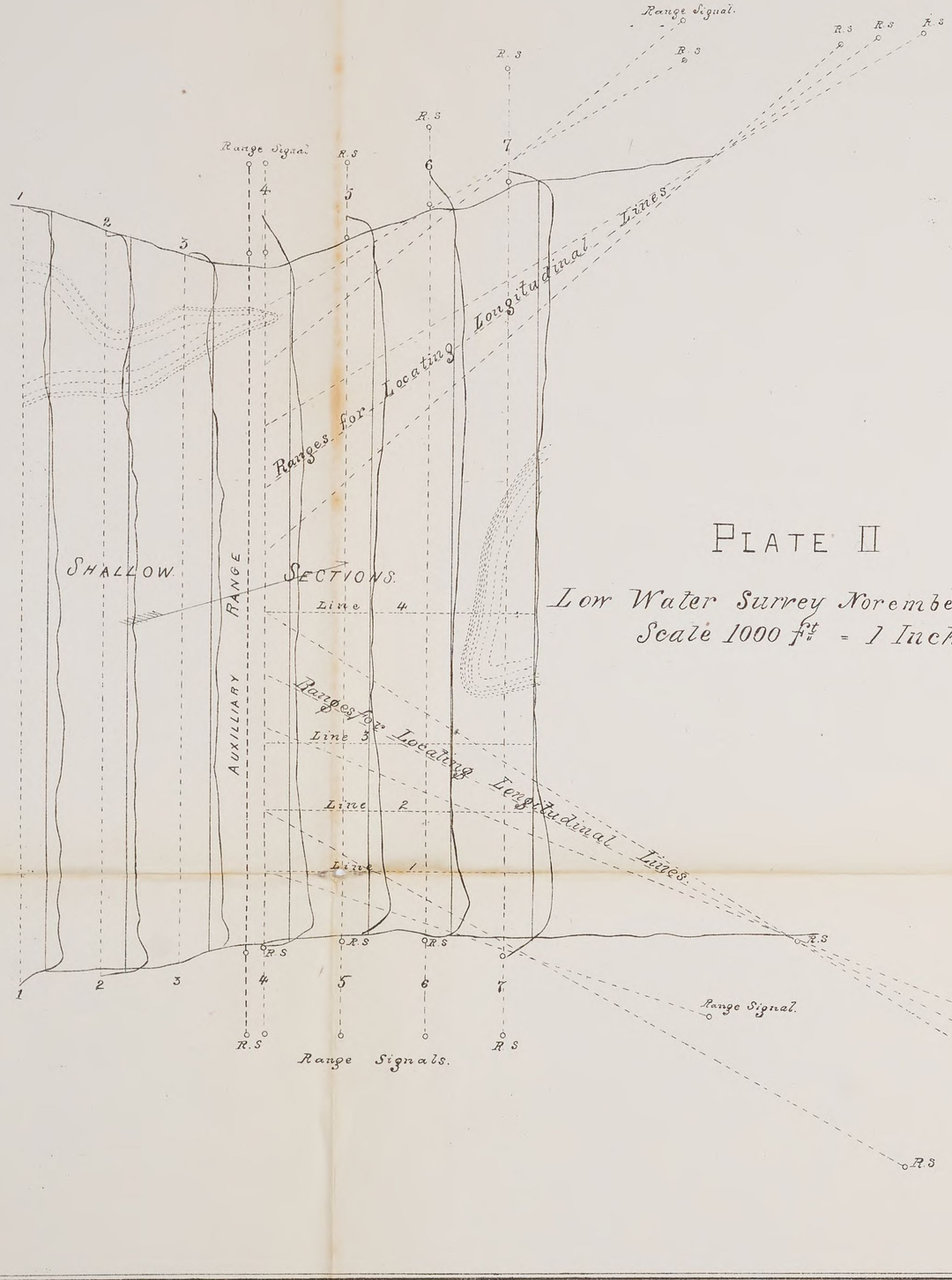
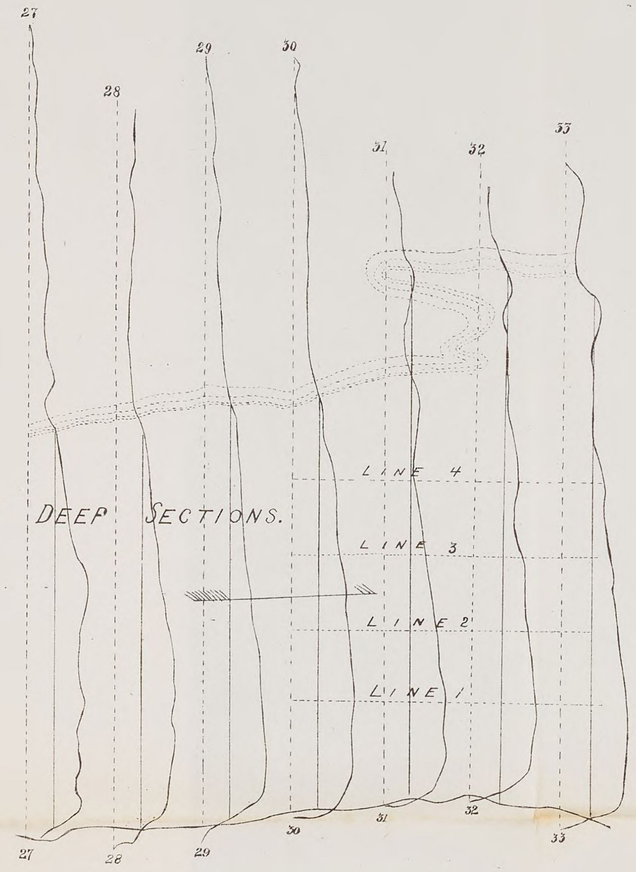


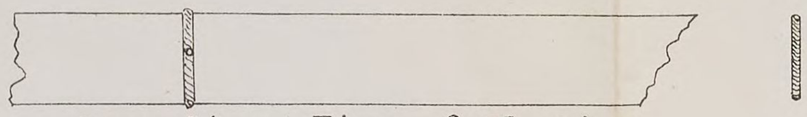
PLATE II

Low Water Survey November 1879
Scale 1000 ft = 1 Inch.

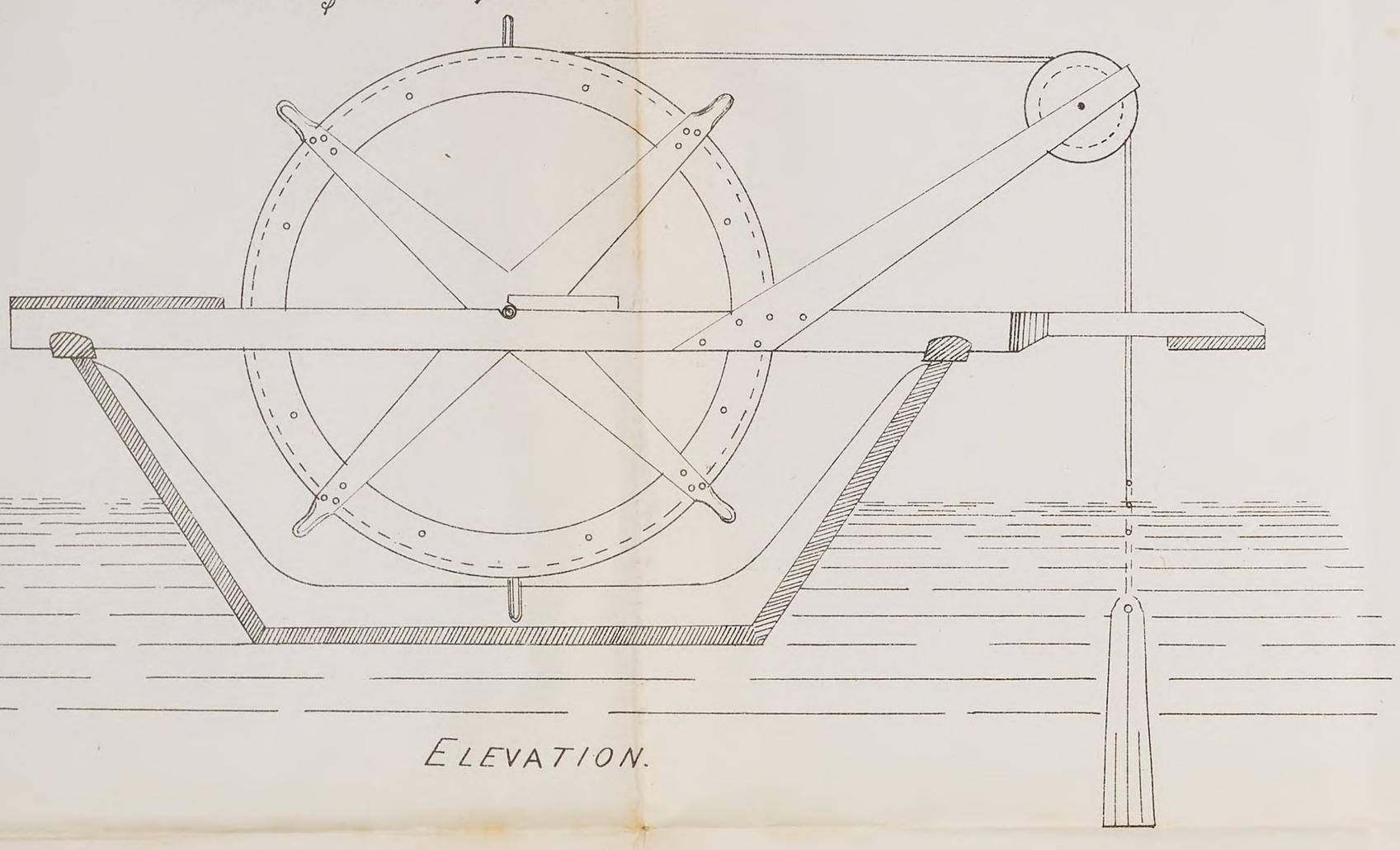




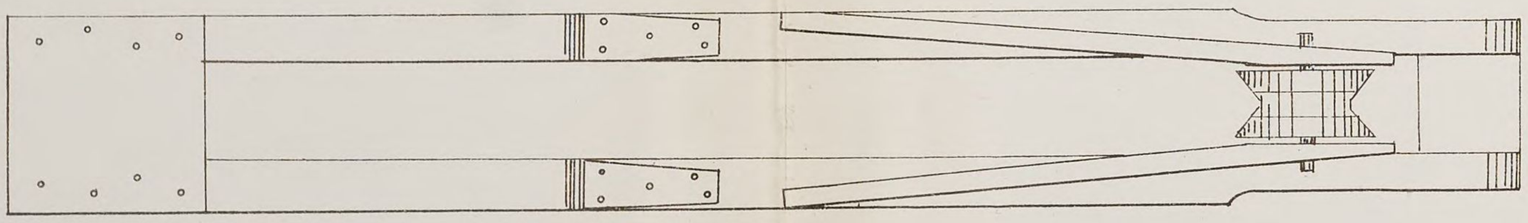
Scale.



Sounding Line full size.

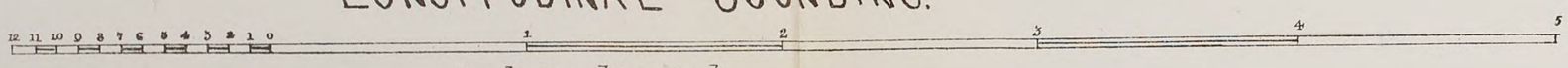


ELEVATION.

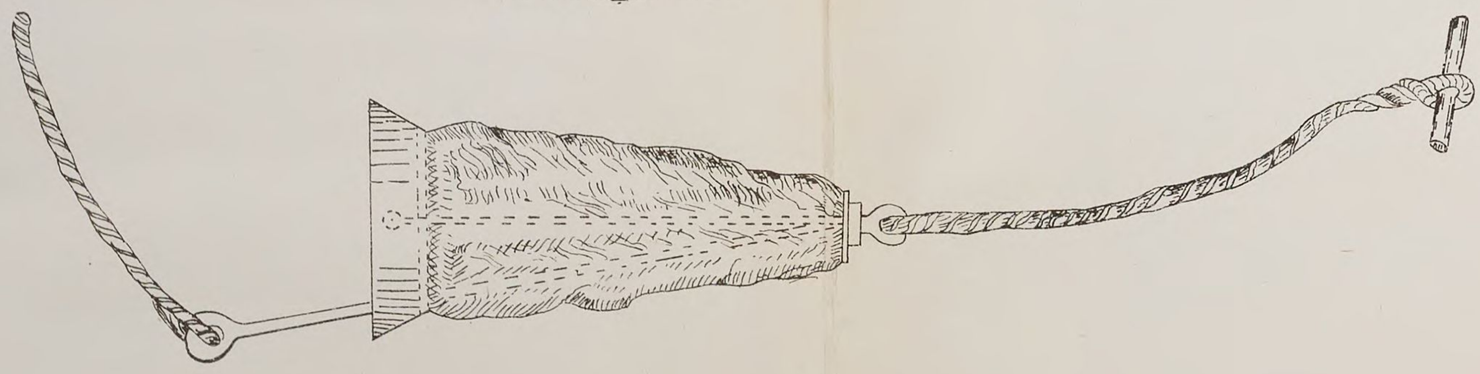


Plan of frame.

APPLIANCE
Used in
LONGITUDINAL SOUNDING.



Scale. 1½ inches = 1 foot.



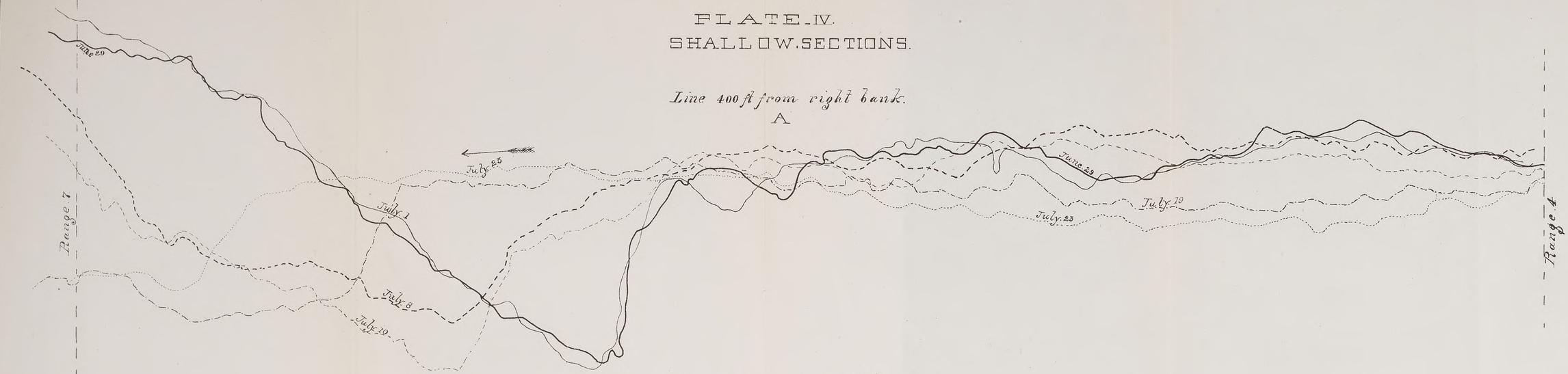
Dredge.

PLATE III.

PLATE IV.
SHALLOW SECTIONS.

Line 400 ft from right bank.

A



Line 400 ft from right bank.

A

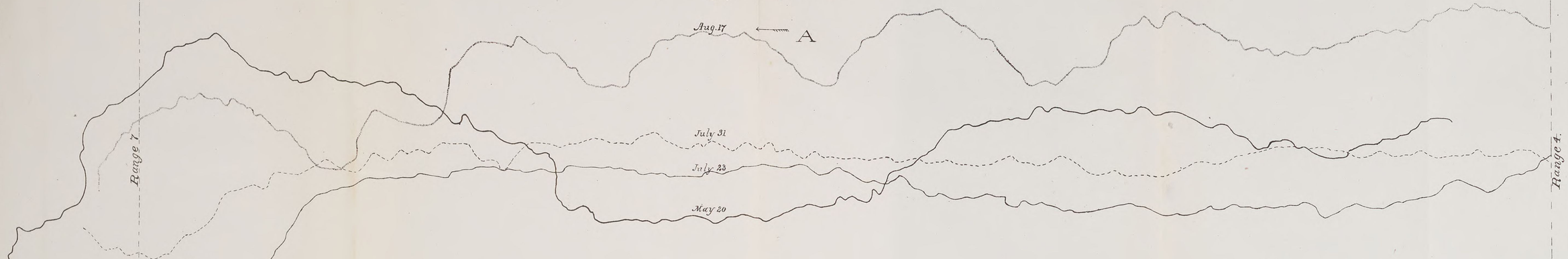
Scale 100 ft horizontal = 1 inch.
" 10 ft Vert. = 1 inch.

Scale of inches

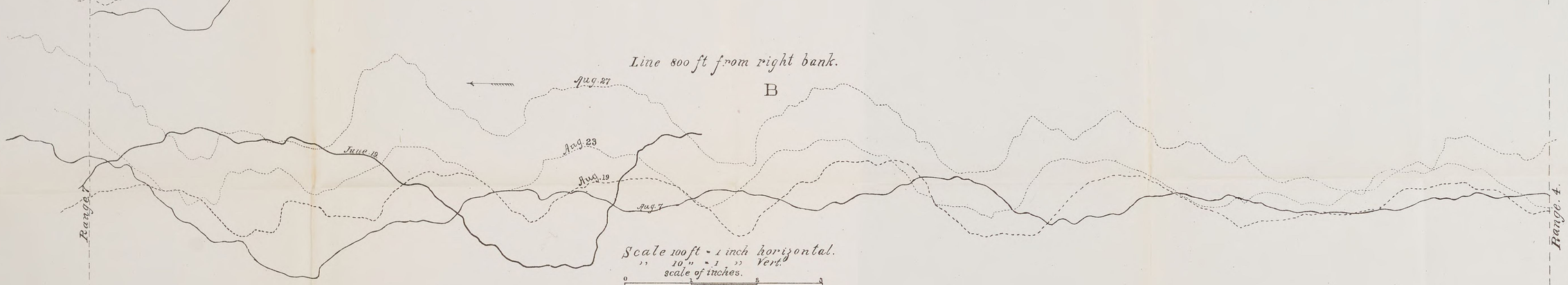
0 1 2 3

PLATE V.
SHALLOW SECTIONS.

Line 400 ft from right bank.



Line 800 ft from right bank.



Scale 100 ft = 1 inch horizontal.
" 10 " = 1 " Vert.
scale of inches.
0 1 2 3

PLATE VI.
SHALLOW SECTIONS.

Line 400 ft from right bank.

A

May 26
May 24
May 22
Range 7
Range 4

Line 800 ft from right bank.

B

May 14
May 17
Range 7
Range 4

Line 1200 ft from right bank.

C

May 26
May 17
May 20
May 22
Range 7
Range 4

Horizontal scale 100 ft = 1 inch.
Vert. " 10 ft = "

Scale of inches
0 1 2 3

PLATE VII

Showing movement of bottom at High water and obliteration of ware by deposit of Sedimentary matter.

River Falling.

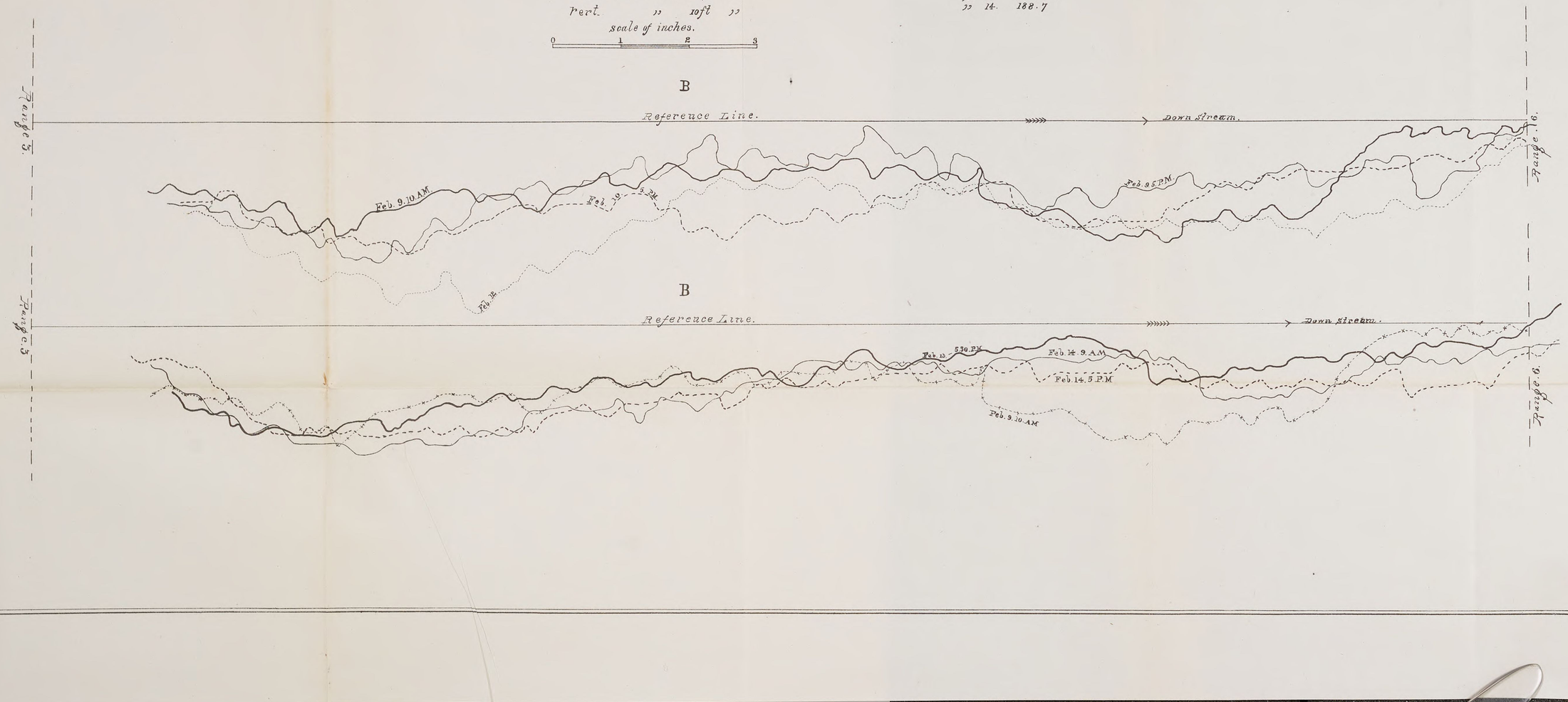
RANGE 3-6

Horizontal scale 100ft 1 inch.
Vert. " 10ft "
Scale of inches.

0 1 2 3

Gauge

Feb.	9.	193.8
"	10.	192.4
"	12.	190.3
"	13.	189.4
"	14.	188.7



Showing movement of bottom at high water and beginning of wave developement, River Stationary.

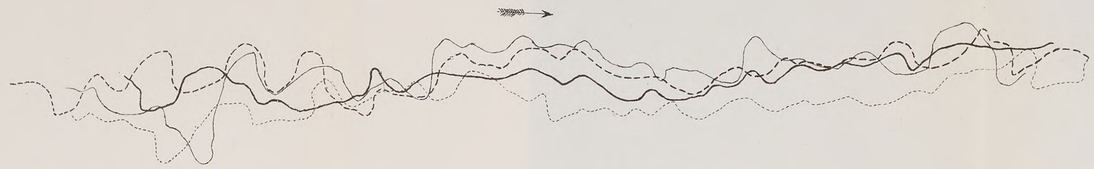
PLATE. VIII.

RANGE. 13-14

Range 13

D

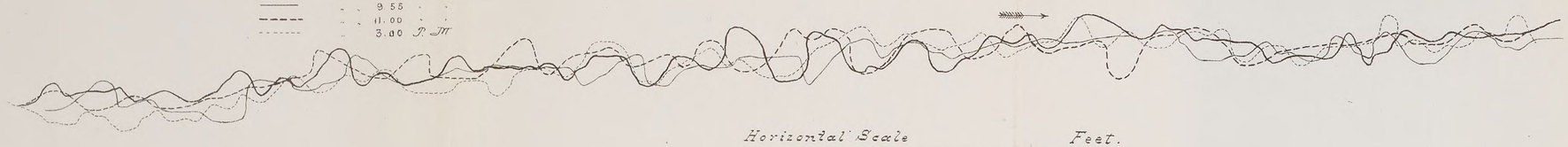
May 4th Gauge 199.3
- 8.30 A. M.
- 10.10 " "
- 2.55 P. M.
- 4.30 " "



Range 13

D

May 5th Gauge 199.3
- 9.00 A. M.
- 9.55 " "
- 11.00 " "
- 3.00 P. M.



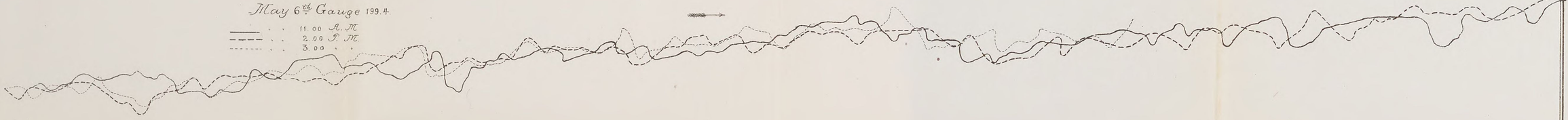
Horizontal Scale Feet.

Vertical Scale Feet.

Range 13

D

May 6th Gauge 199.4
- 11.00 A. M.
- 2.00 P. M.
- 3.00 " "



Range 13

D

May 7th Gauge 199.5
- 8.30 A. M.
- 10.30 " "
- 2.00 P. M.
- 4.00 " "
- 5.00 " "

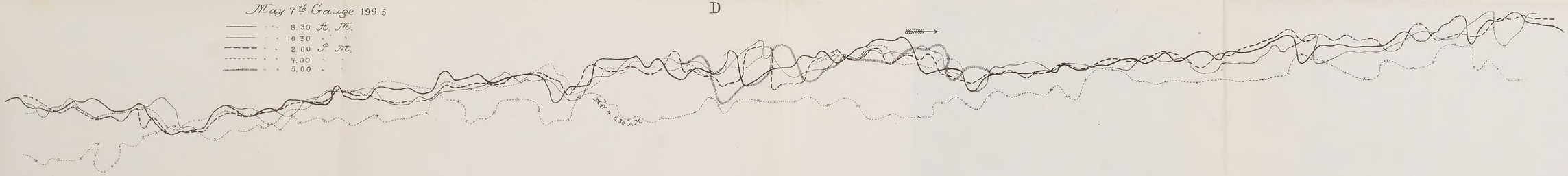


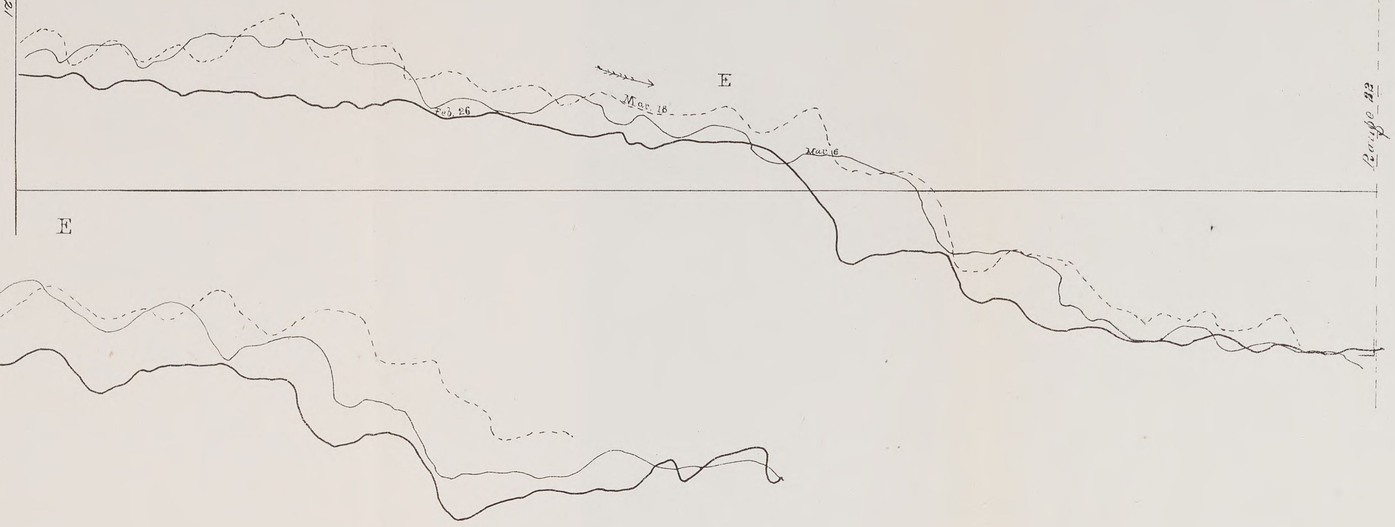
PLATE IX.

Scale 100ft: 1inch horizontal.
" 10ft = " vert.
Scale of inches 0 1 2 3

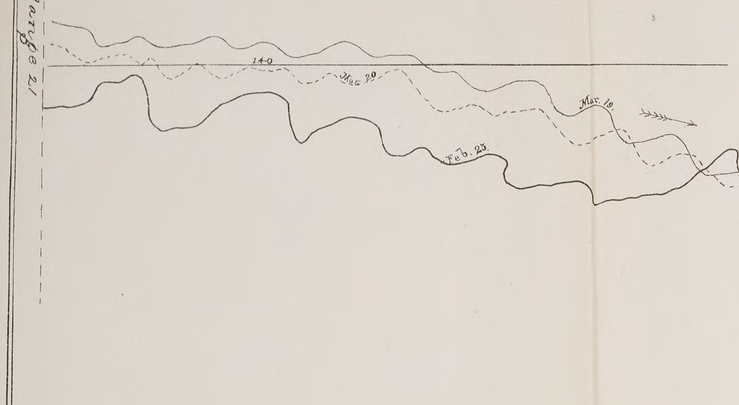
Showing method of bar accretion.

RANGE 21-22.

Line 800ft from right bank.

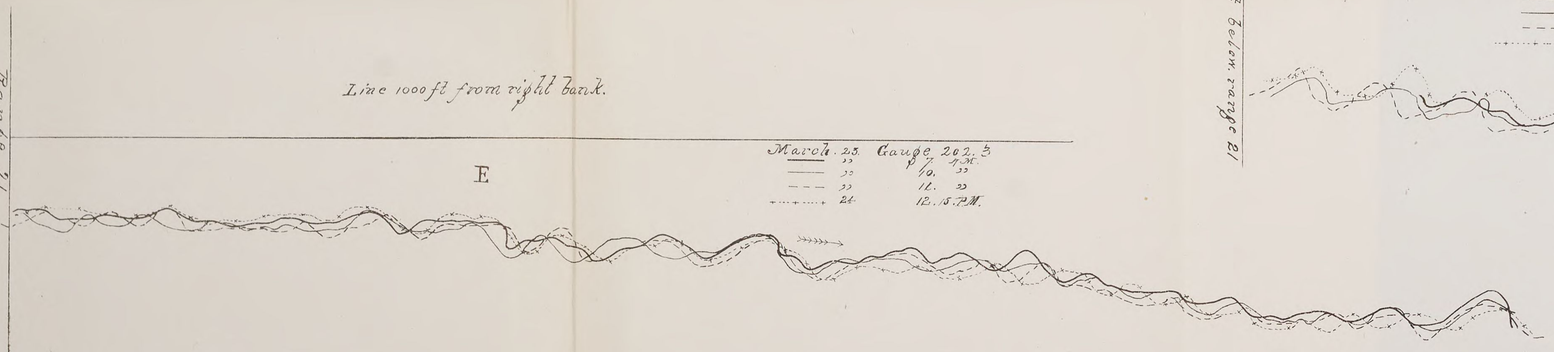


Line 800ft from right bank.



Line 1000ft from right bank.

March 23. Gauge 202.3
" 7. P.M.
" 9. "
" 11. "
24 12.15 P.M.



Line 1000ft from right bank.

March 22 Gauge 202.3
" 11.20. P.M.
" 2.00. P.M.
" 5.15 "
24 11.15. P.M.

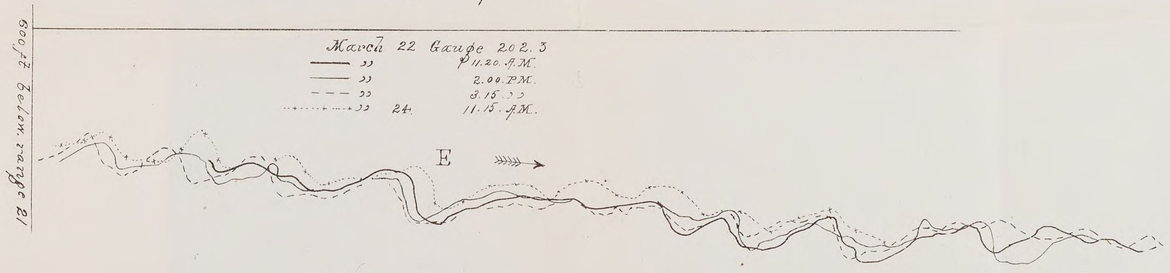


PLATE X.

Showing Change in bottom at Low, Medium Stage, and High Water.

Plotted from Mean Depths of Sections.

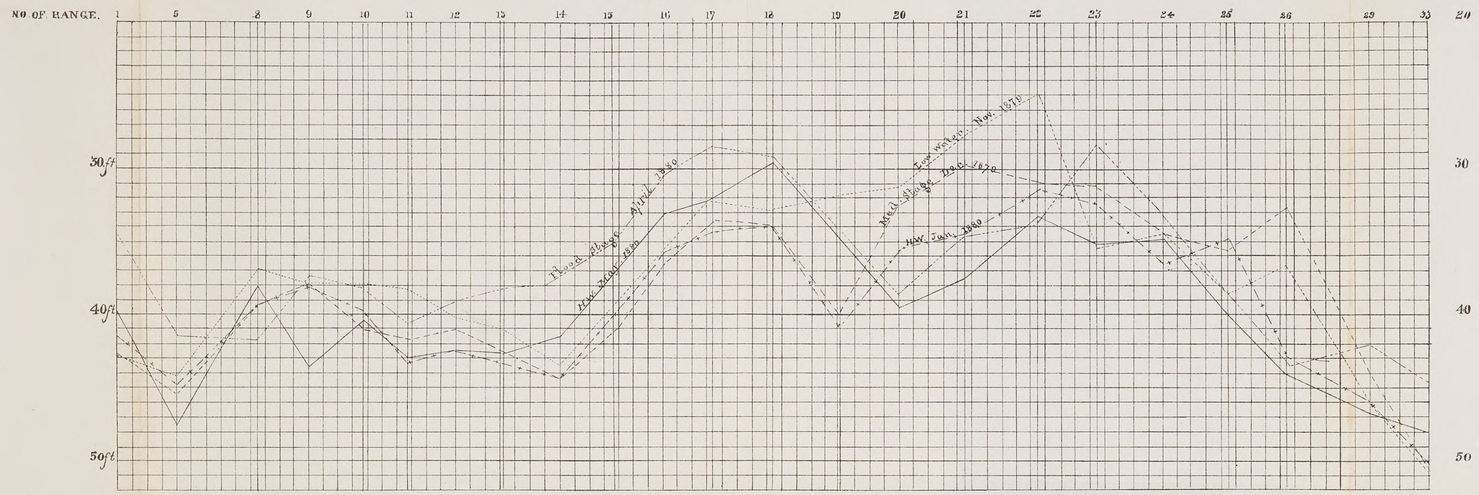
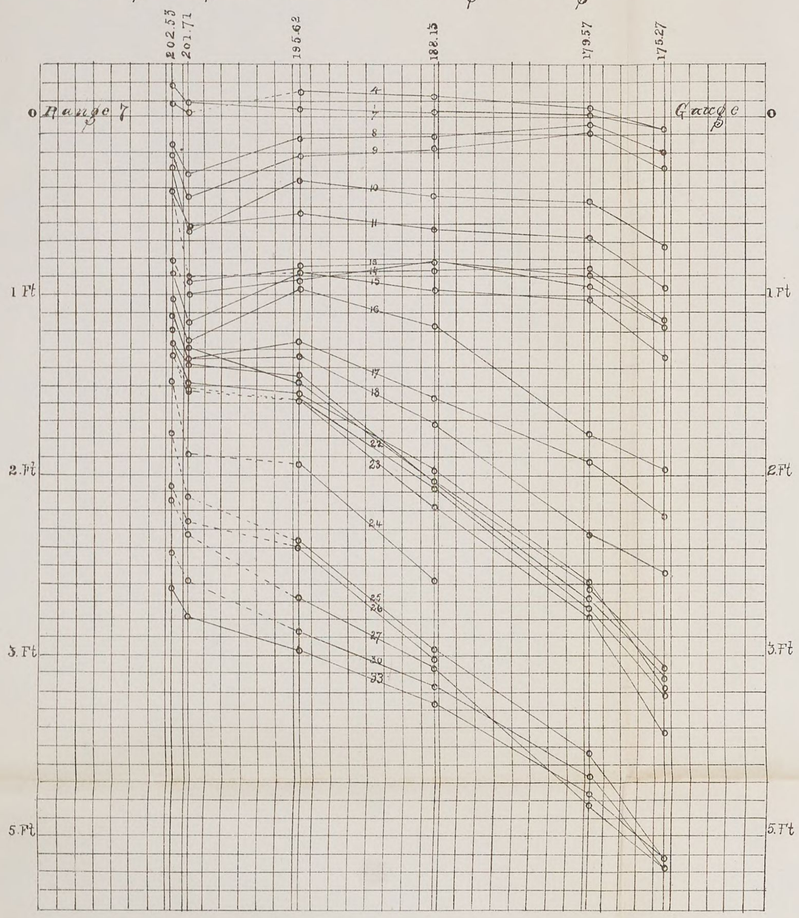


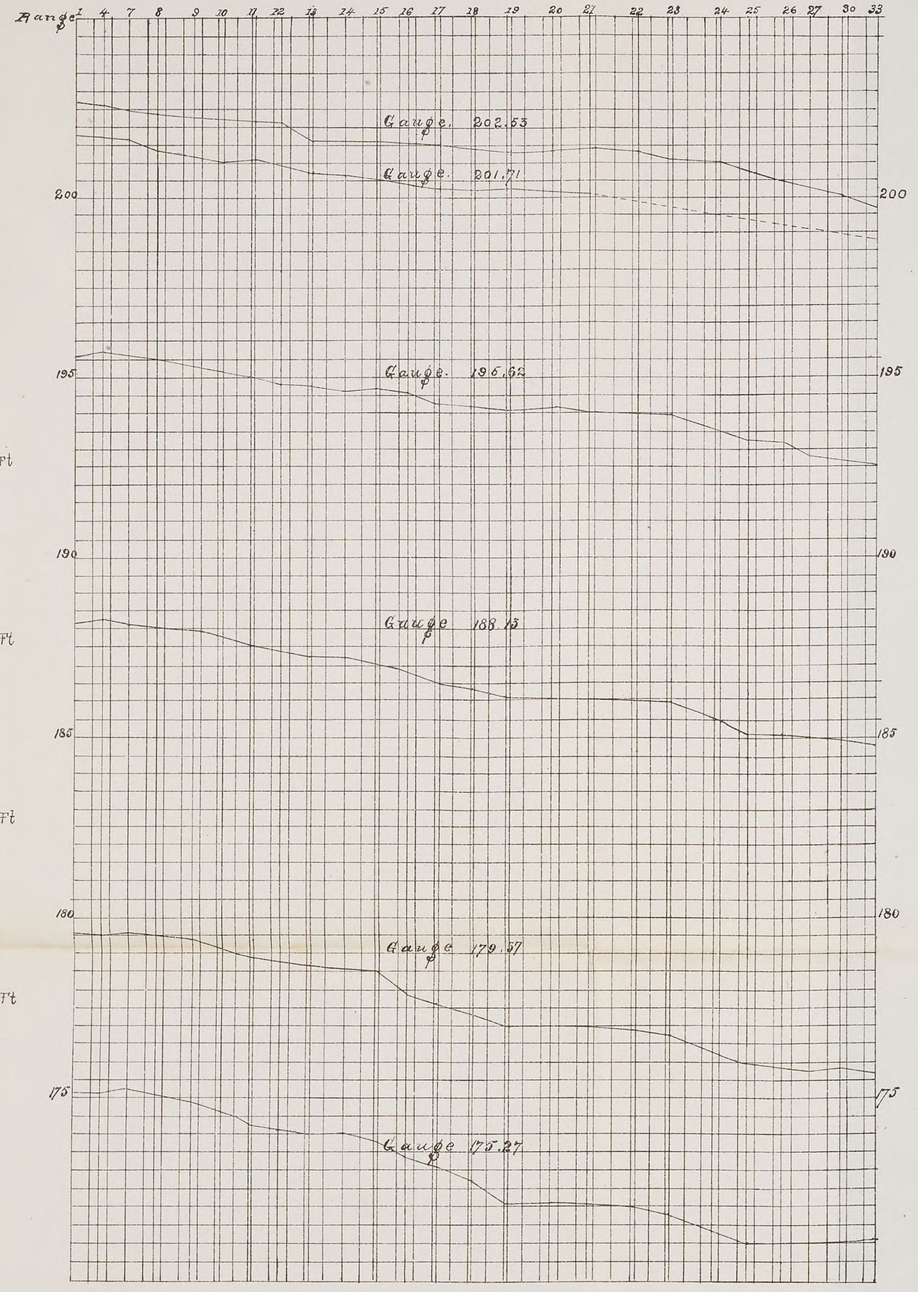
PLATE. XI.

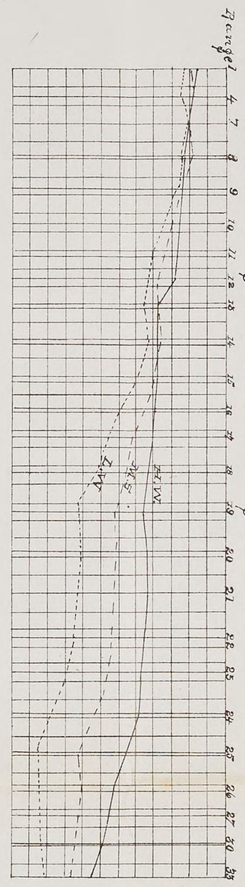
SLOPE. PROFILE.

DIAGRAM.

Showing Change in Slope due to Change in Stage.

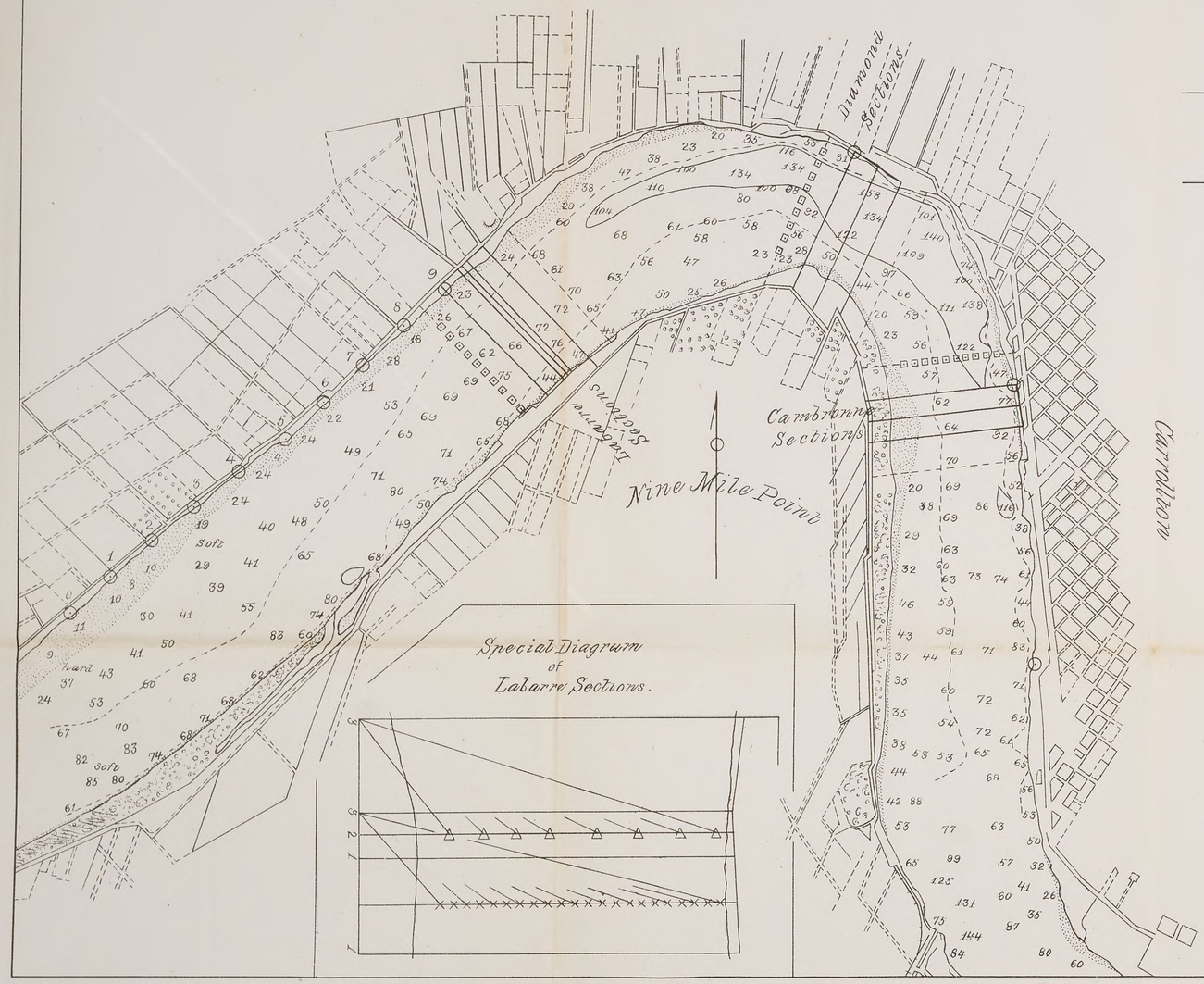






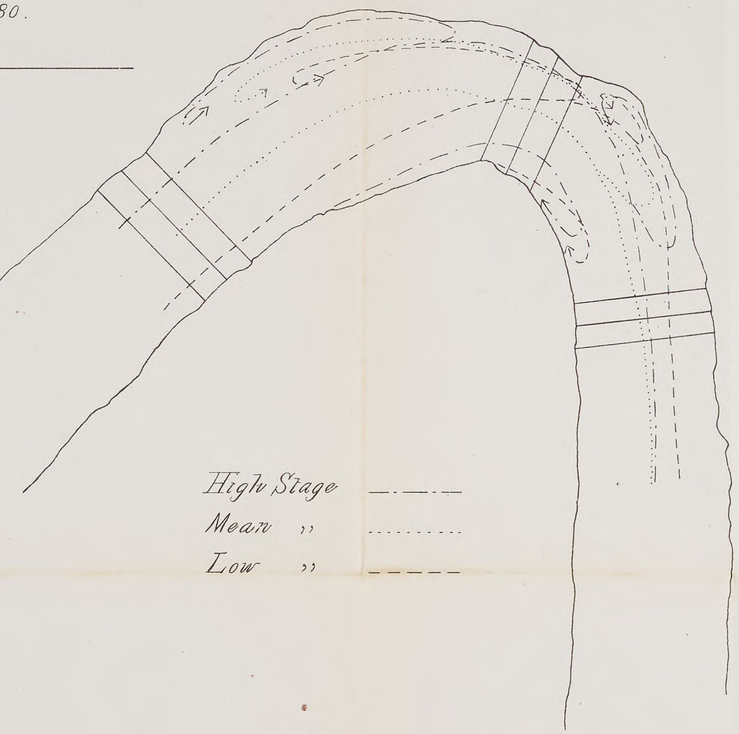
□ *Initial Points of Longitudinal Lines.*
○ *Slope Stations.*
△ *Sediment Positions.*
× *Initial Float Positions.*

Fig. 1
General Map of Locality.



Observations
at
Carrollton La.
1879-80.

Fig. 2
Directions of Currents
at
Different Stages.



Statute Miles
0 ¼ ½ 1
Yards.
1000 500 0 1000
Kilometers.
1 0 1

Fig. 1.
Relation of
Discharge and Gauge.

Fig. 2.
Relation of
Mean Velocity
and
Gauge.

Fig. 3.
Relation of
Mean Velocity
and
Discharge.

1. Dec. 17. R.
2. Jan. 3. R.
3. " 16. R.
4. " 26. R.
5. Feb. 13. F.
6. Mar. 5. R.
7. " 18. R.
8. Apr. 1. R.
9. May 21. F.
10. June 1. F.
11. " 12. S.
12. " 16. S.
13. " 19. F.
14. " 24. F.
15. June 29. S.
16. July 2. R.
17. " 8. R.
18. " 16. R.
19. " 24. R.
20. " 31. S.
21. Aug. 5. F.
22. " 9. F.
23. " 16. F.
24. " 20. F.
25. " 24. F.
26. " 27. S.
27. Sept. 3. R.
28. " 13. R.
29. Sept. 18. R.
30. " 21. R.
31. " 30. F.
32. Oct. 8. F.

R. - Rising.
S. - Stationary.
F. - Falling

Gauge.

Discharge, Cu. Ft. per Sec.

0 100000 200000 300000 400000 500000 600000 700000 800000 900000

Velocity. Ft. per Sec.

Mean Velocity Ft. per Sec.

0 1 2 3 4 5 6

Gauge.

0 2 4 6 8 10 12 14

Fig. 1.

Slope Profiles.

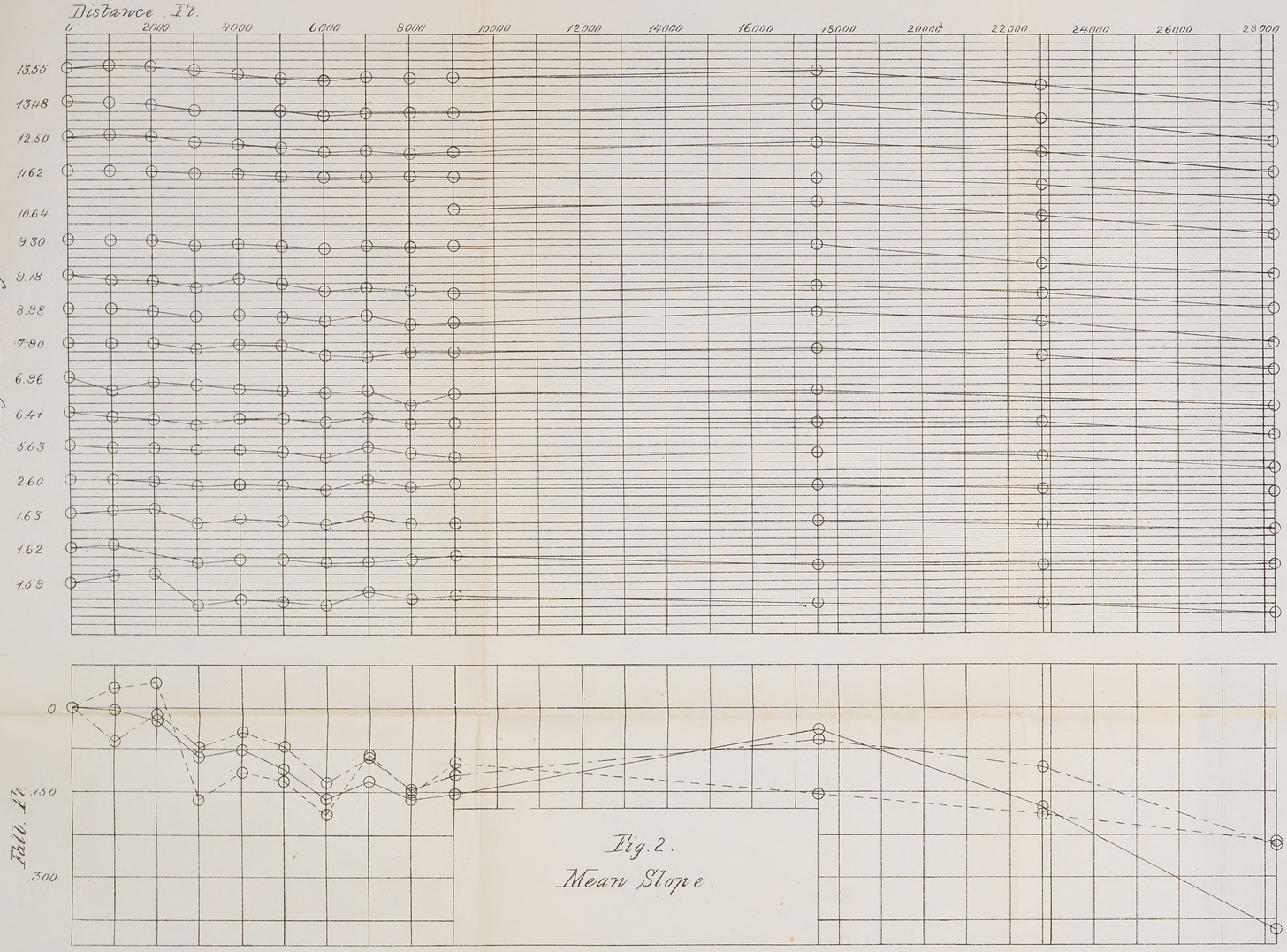


Fig. 2.

Mean Slope.

Observations
at
Carrollton La.
1879-80.

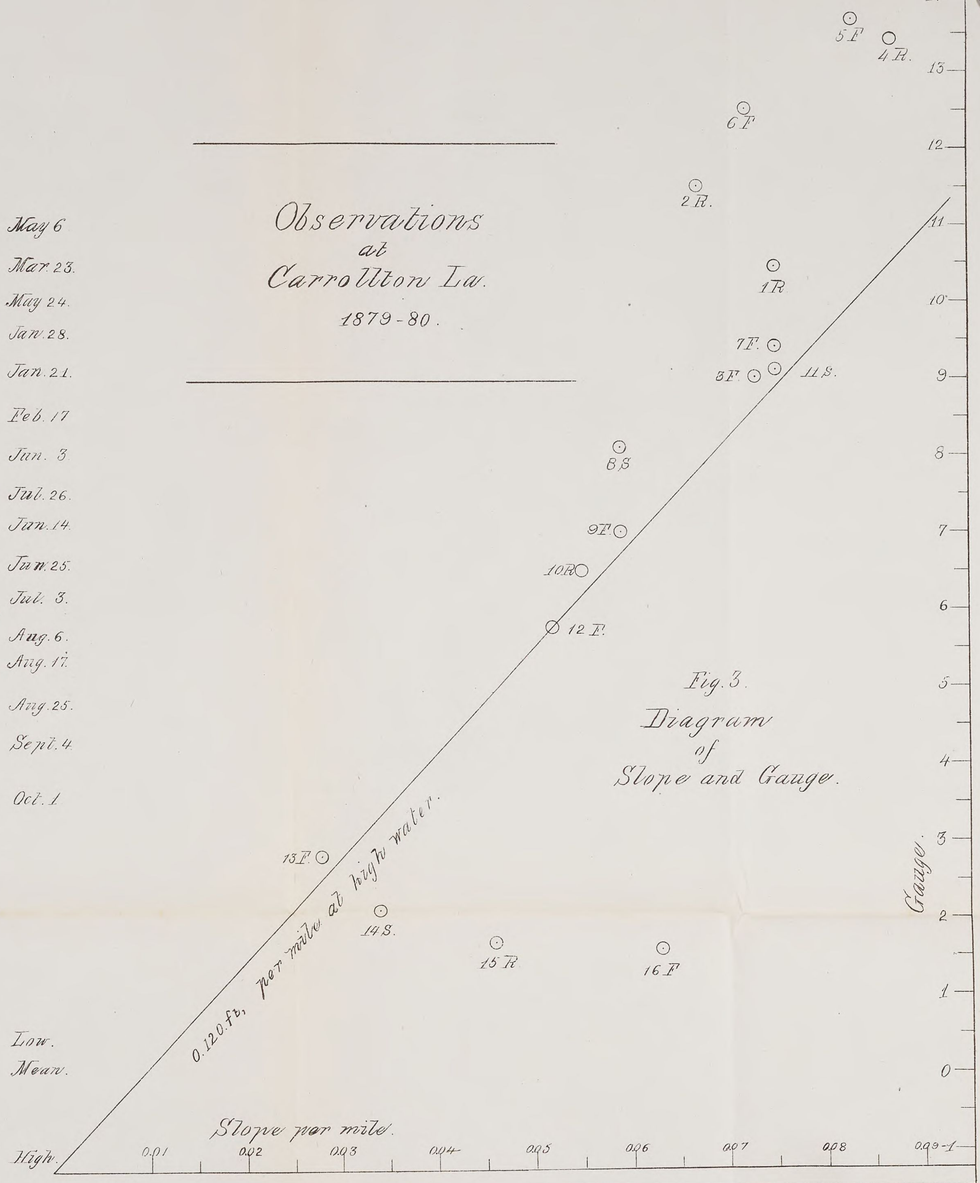


Fig. 3.

Diagram
of
Slope and Gauge.

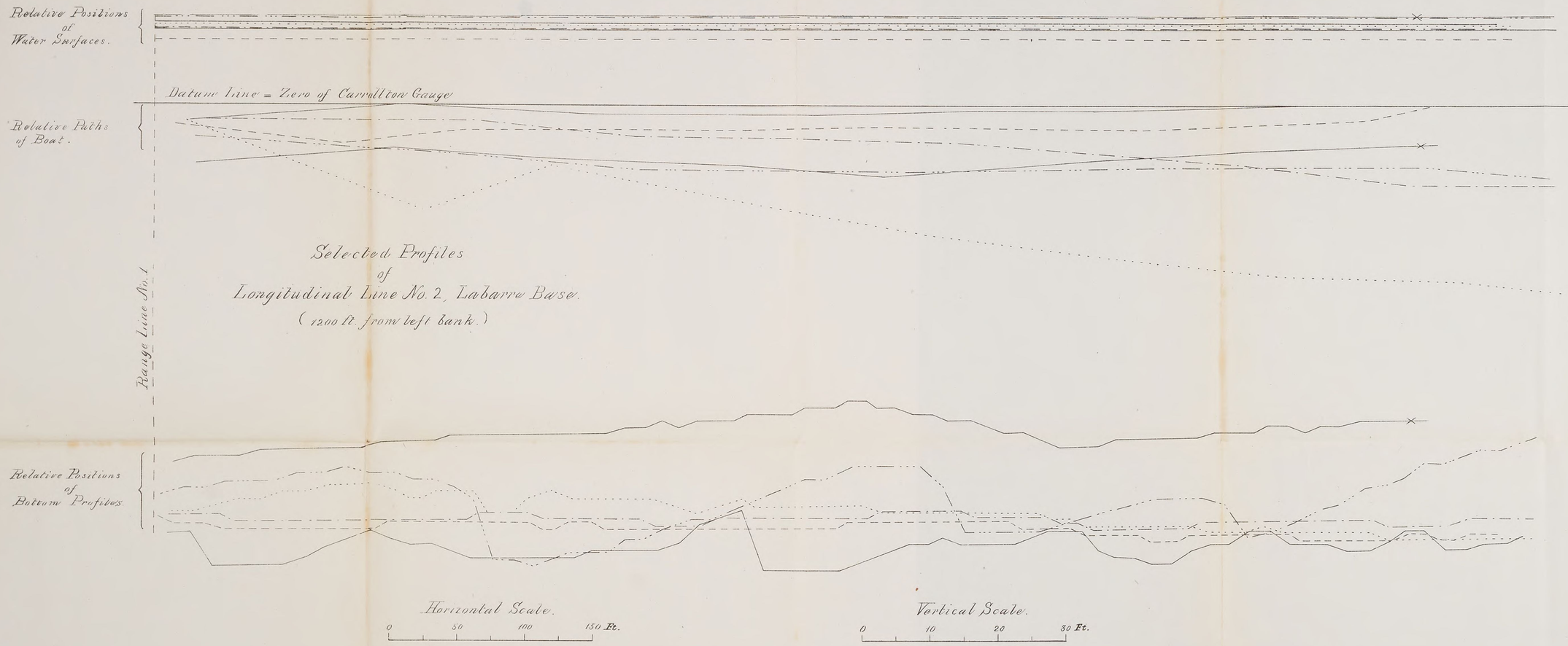
Observations at Carrollton, La.

1879-80.

Jan. 27 ——— Gauge 11.4
Feb. 14 – – – – ,, 10.1
Mar. 3 — · — · — ,, 11.5
Mar. 13 ..... ,, 12.6
Apr. 6 — ... — ,, 13.4
May 3 —×— ,, 13.5

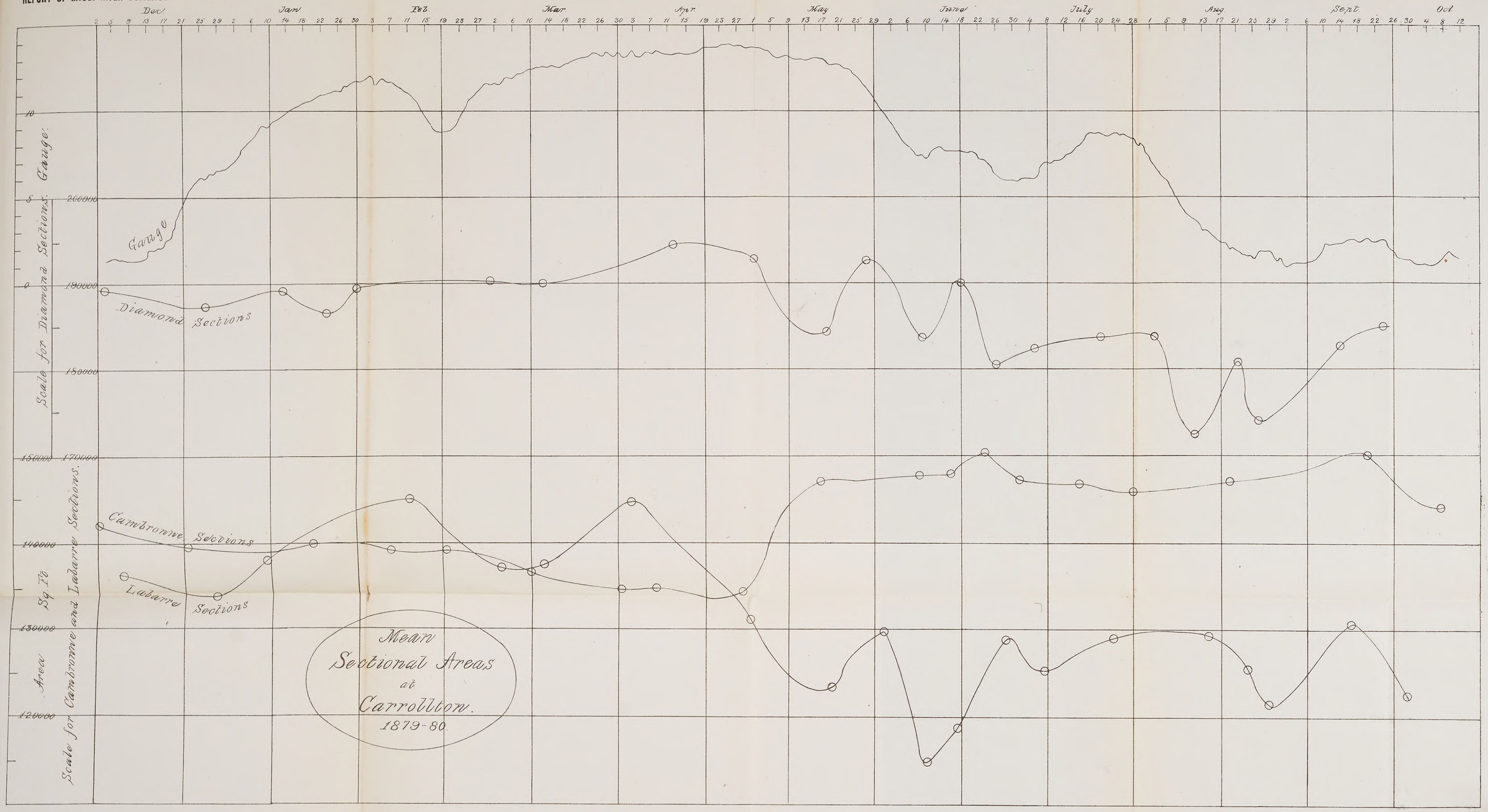
Note.

The Water Surface, Path of Boat, and Profile of Bottom of each Survey is represented by its characteristic line.

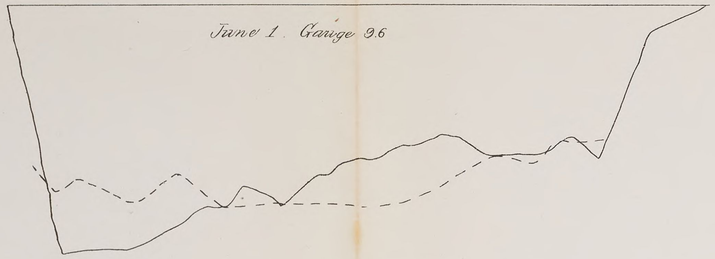


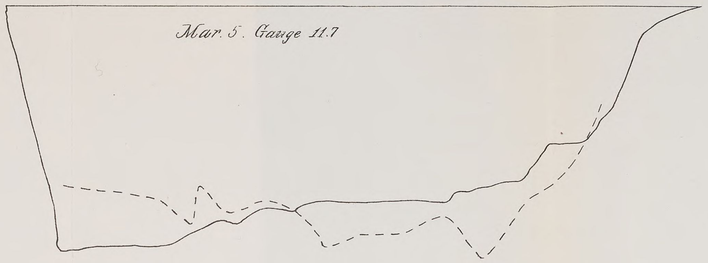
REPORT OF MISS. RIVER COMMISSION. 1882.

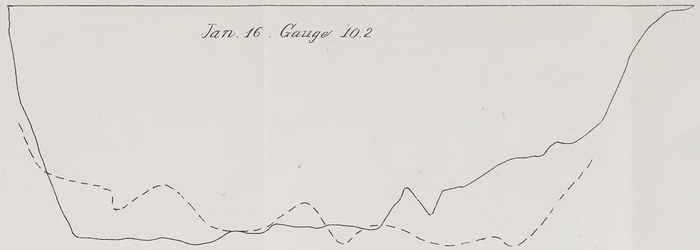
APPENDIX E, PLATE V.

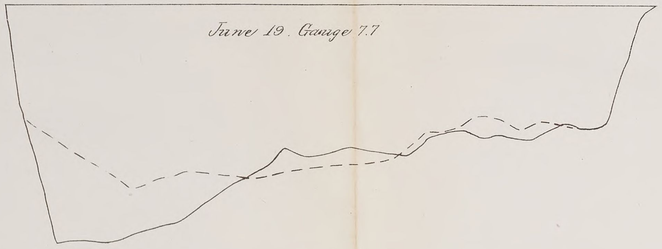


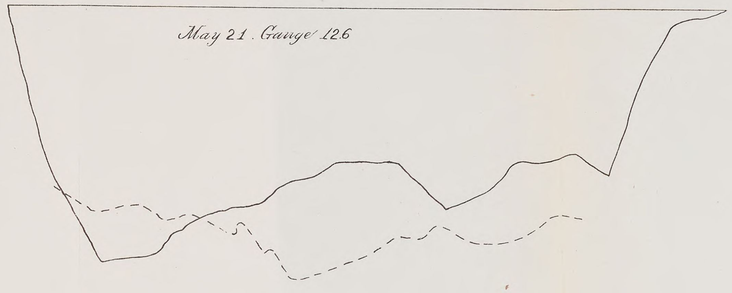
Mean
Sectional Areas
at
Carrollton.
1879-80.

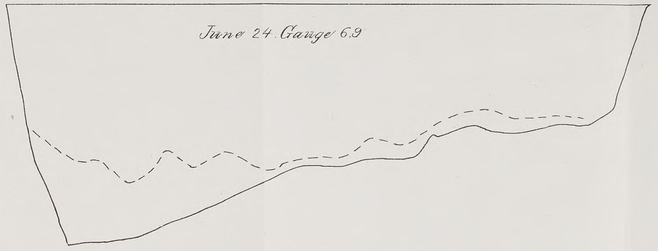




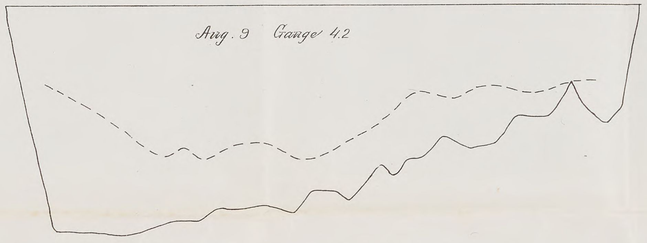


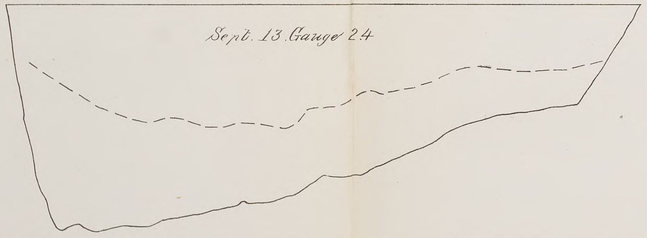


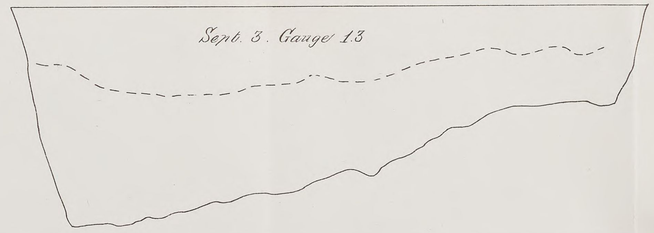




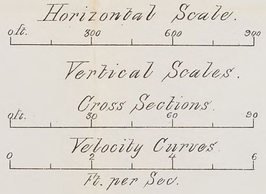








Mid-Depth Velocity Curves at Carrollton, La. 1879-80, and Corresponding Cross Sections.

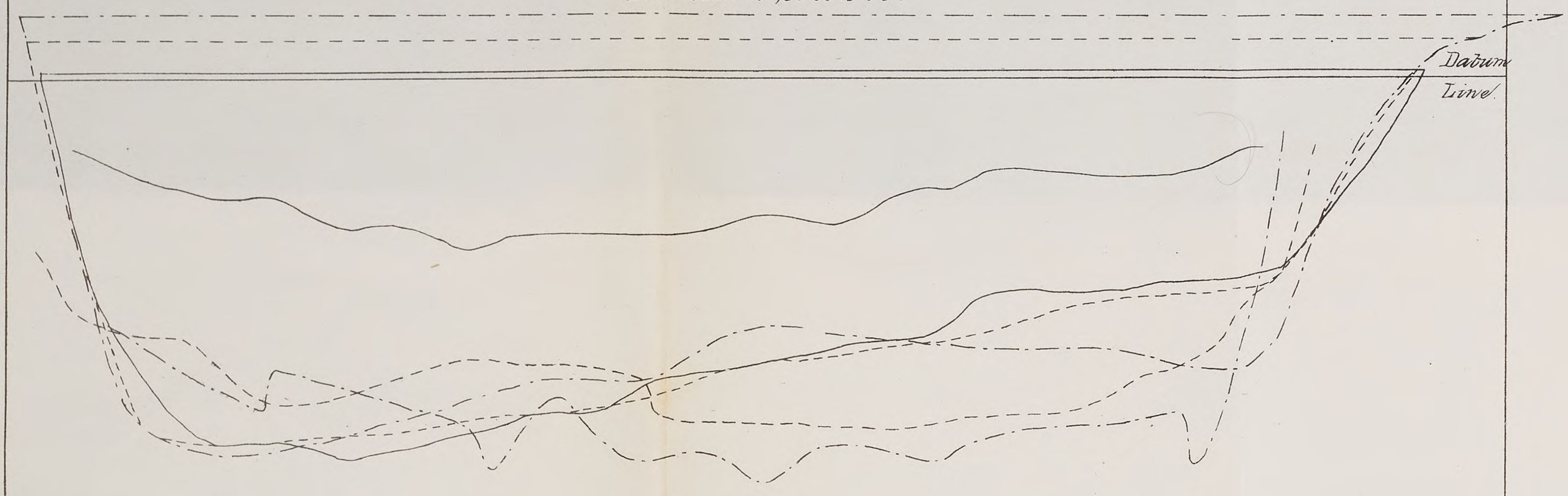


Mean Sections and Transverse Velocity Curves
at
Carrollton, La.
1879-80.

High Water Secs. and Curves — · —
Mean Stage " " " – – – –
Low Water " " " ———

Datum Line = Zero of Carrollton Gauge.
Water Surfaces plotted at Mean Gauge Readings above Datum Lines.
Velocity Curves plotted from the Datum Lines.

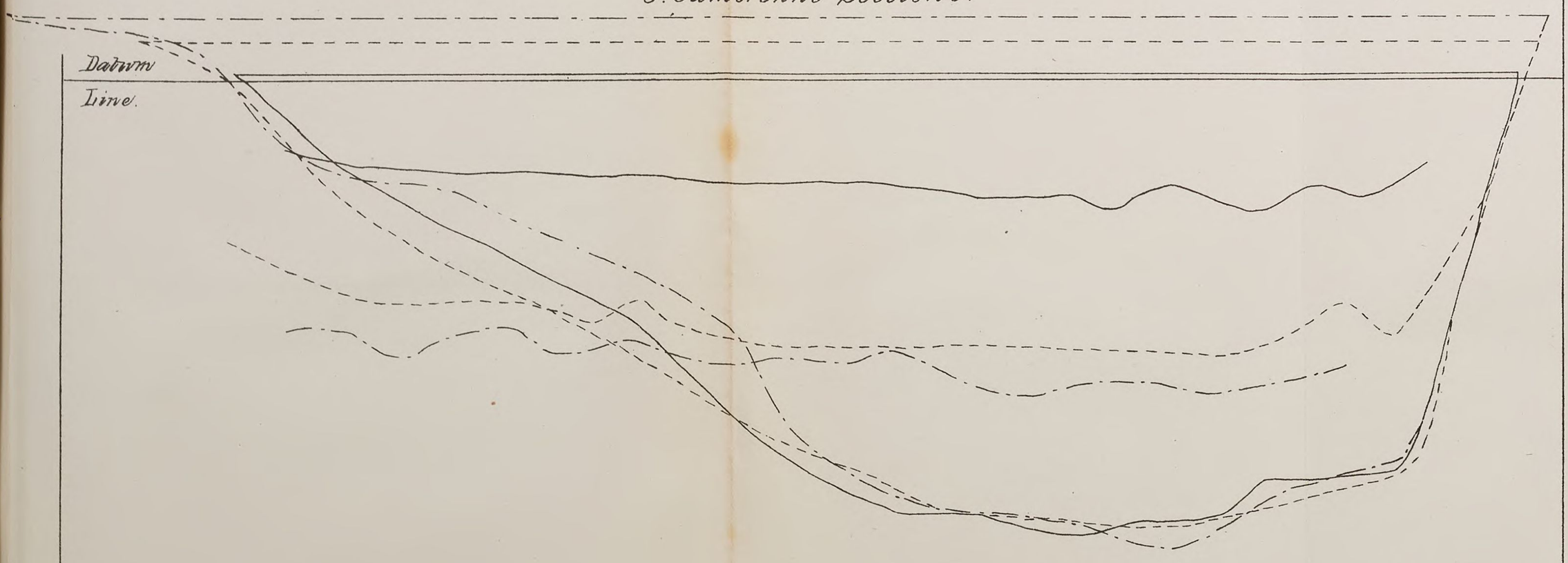
1. Labarre Sections.



2. Diamond Sections.



3. Cambronne Sections.



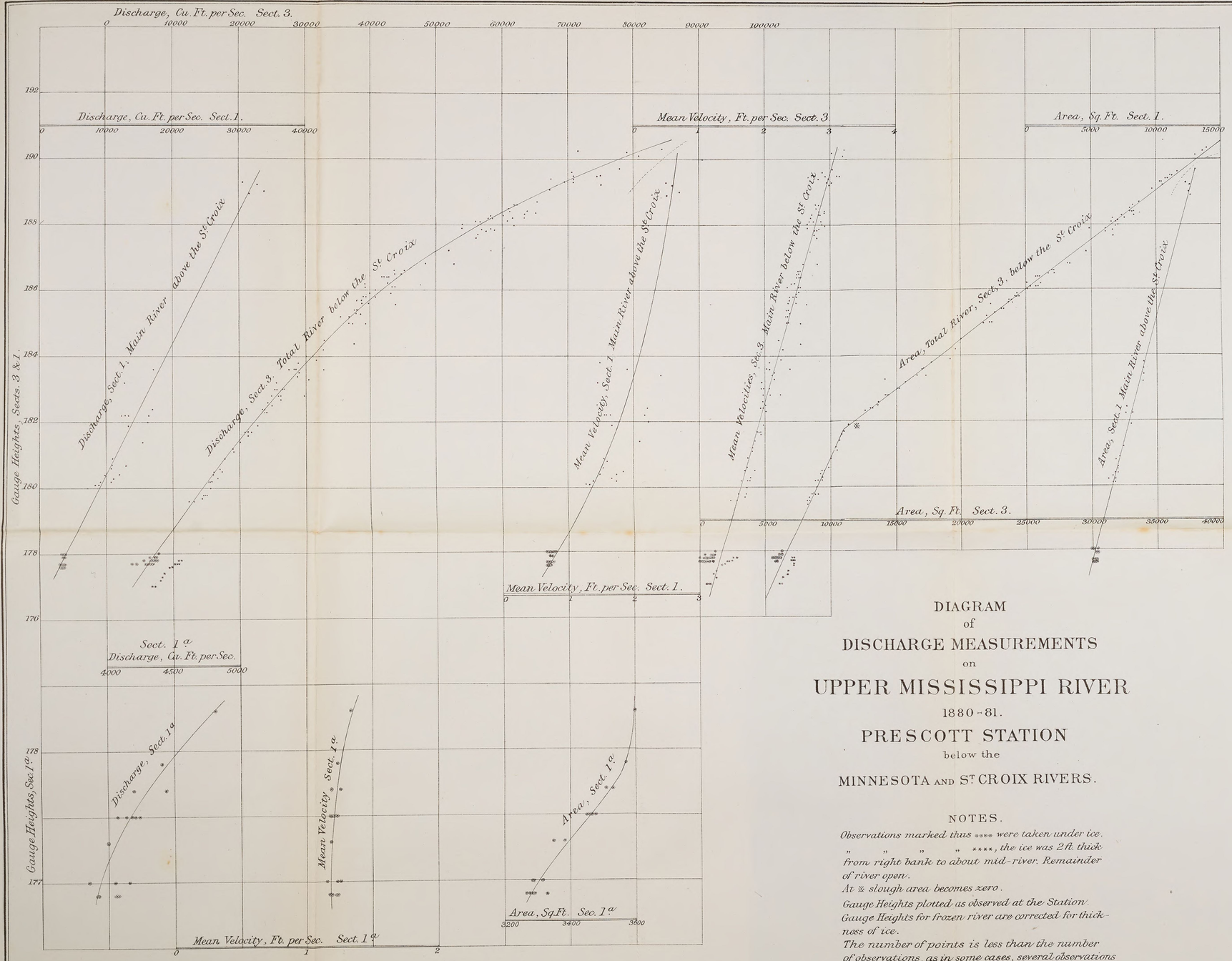


DIAGRAM
of
DISCHARGE MEASUREMENTS
on
UPPER MISSISSIPPI RIVER
1880-81.
PRESCOTT STATION
below the
MINNESOTA AND St. CROIX RIVERS.

NOTES.

*Observations marked thus **** were taken under ice.*
" " " " ×××× , the ice was 2 ft. thick from right bank to about mid-river. Remainder of river open.
At ※ slough area becomes zero.
Gauge Heights plotted as observed at the Station.
Gauge Heights for frozen river are corrected for thickness of ice.
The number of points is less than the number of observations, as in some cases, several observations fall within the same point.

DIAGRAM
showing location of discharge sections,
PRESCOTT.

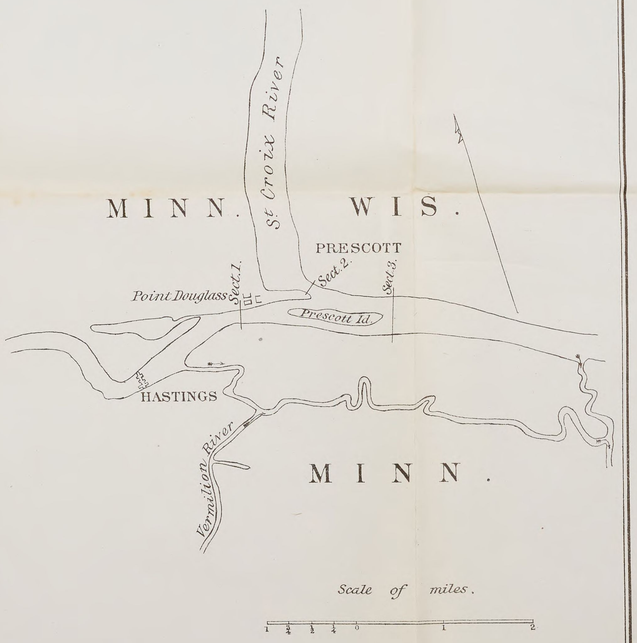


DIAGRAM
of
DISCHARGE MEASUREMENTS
on
UPPER MISSISSIPPI RIVER
1880-81.
WINONA STATION
below the
CHIPPEWA RIVER.

Notes.

Observations marked thus ..... were taken under the ice.

Gauge heights and areas are reduced to the plane of the under surface of the ice.

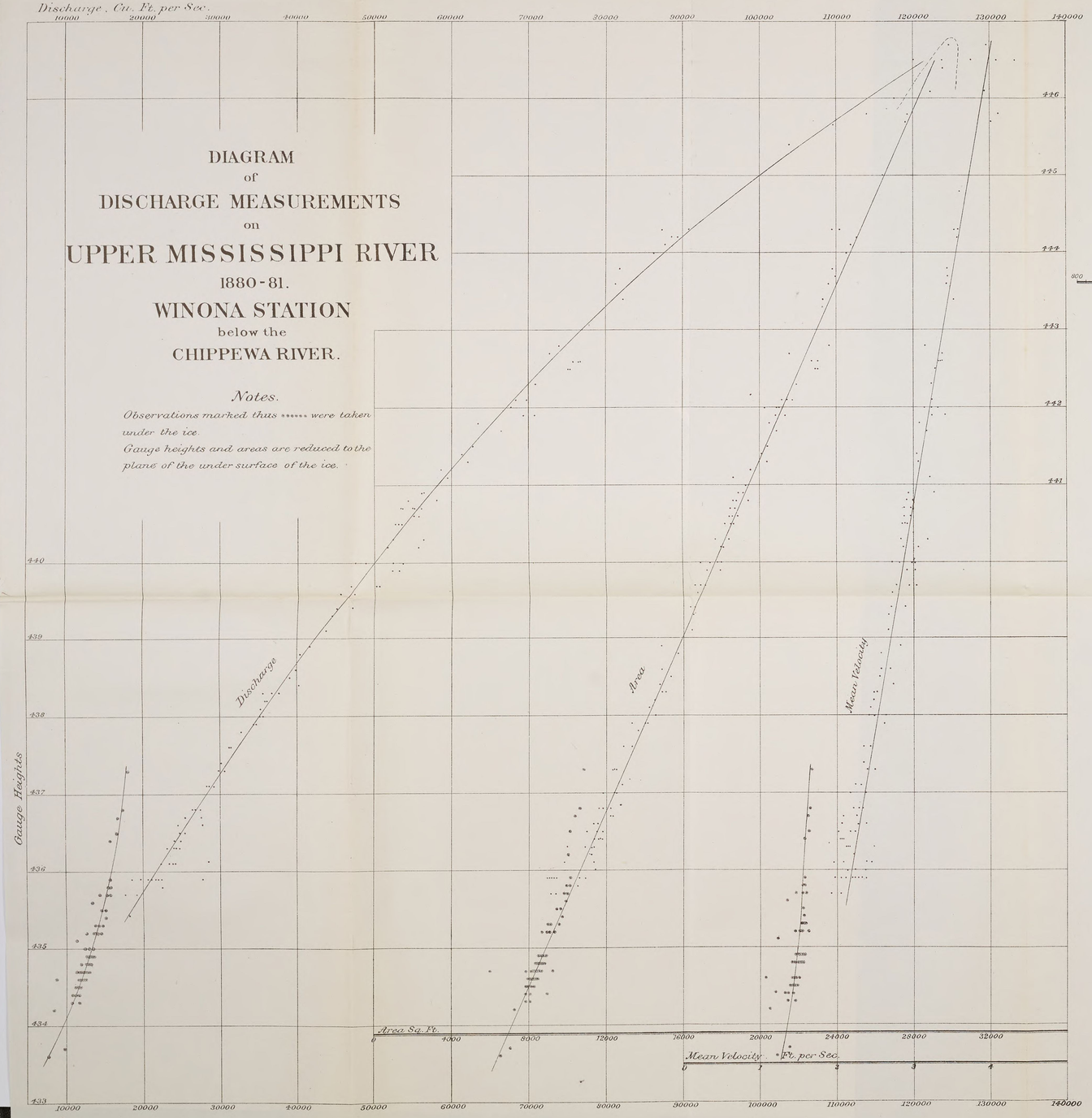


DIAGRAM
showing location of discharge section.
WINONA.

800 400 0 800 1600 2400 3200 ft.

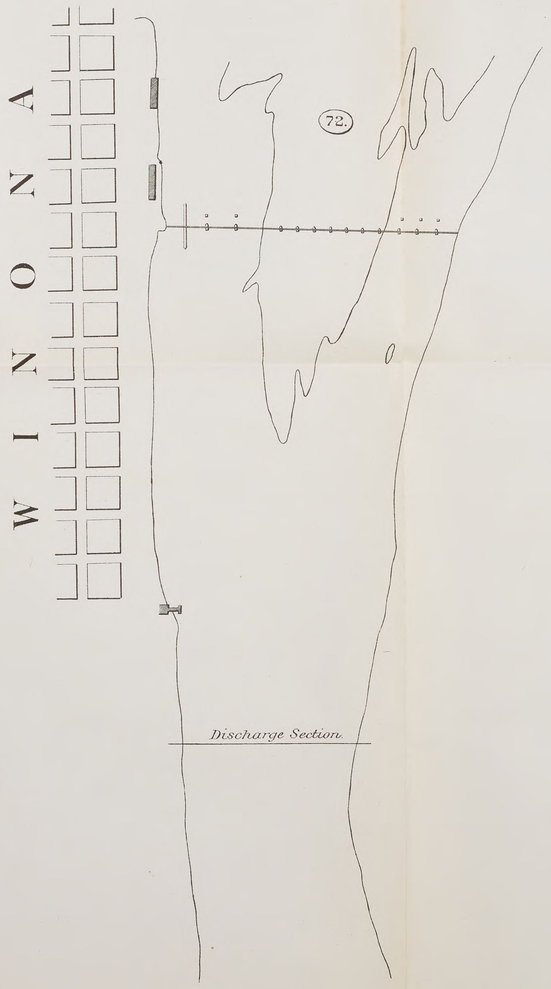


DIAGRAM
of
DISCHARGE MEASUREMENTS
on
UPPER MISSISSIPPI RIVER
1880-81.
CLAYTON STATION
below the
WISCONSIN RIVER.

Notes.

Observations marked thus ..... were taken under the ice.

Zero of gauge, 1 ft. above low water of 1874.

Gauge heights for frozen river are corrected for thickness of ice.

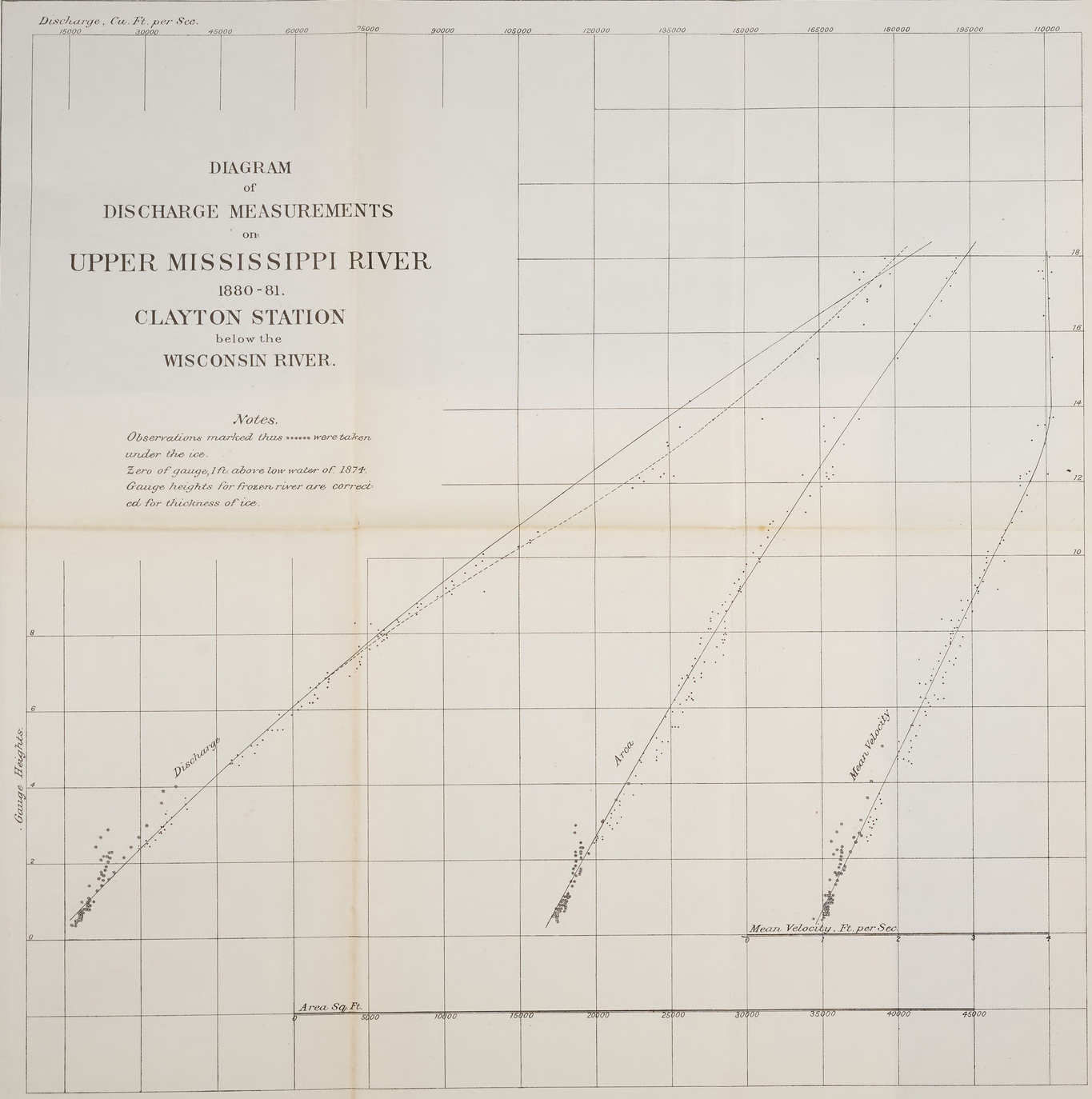


DIAGRAM
showing location of discharge section.
CLAYTON.

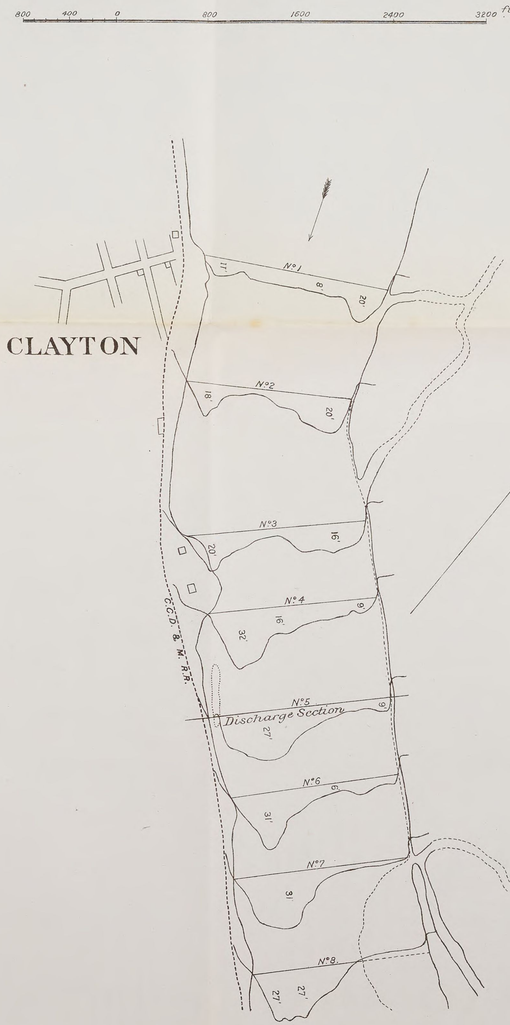


DIAGRAM
of
DISCHARGE MEASUREMENTS
on
UPPER MISSISSIPPI RIVER
1880-81.
HANNIBAL STATION
below the
DES MOINES RIVER.

Notes.

*Observations marked thus ****** were taken under the ice.*

Gauge Heights plotted as observed at the Station.

Gauge Heights for frozen river are corrected for thickness of ice.

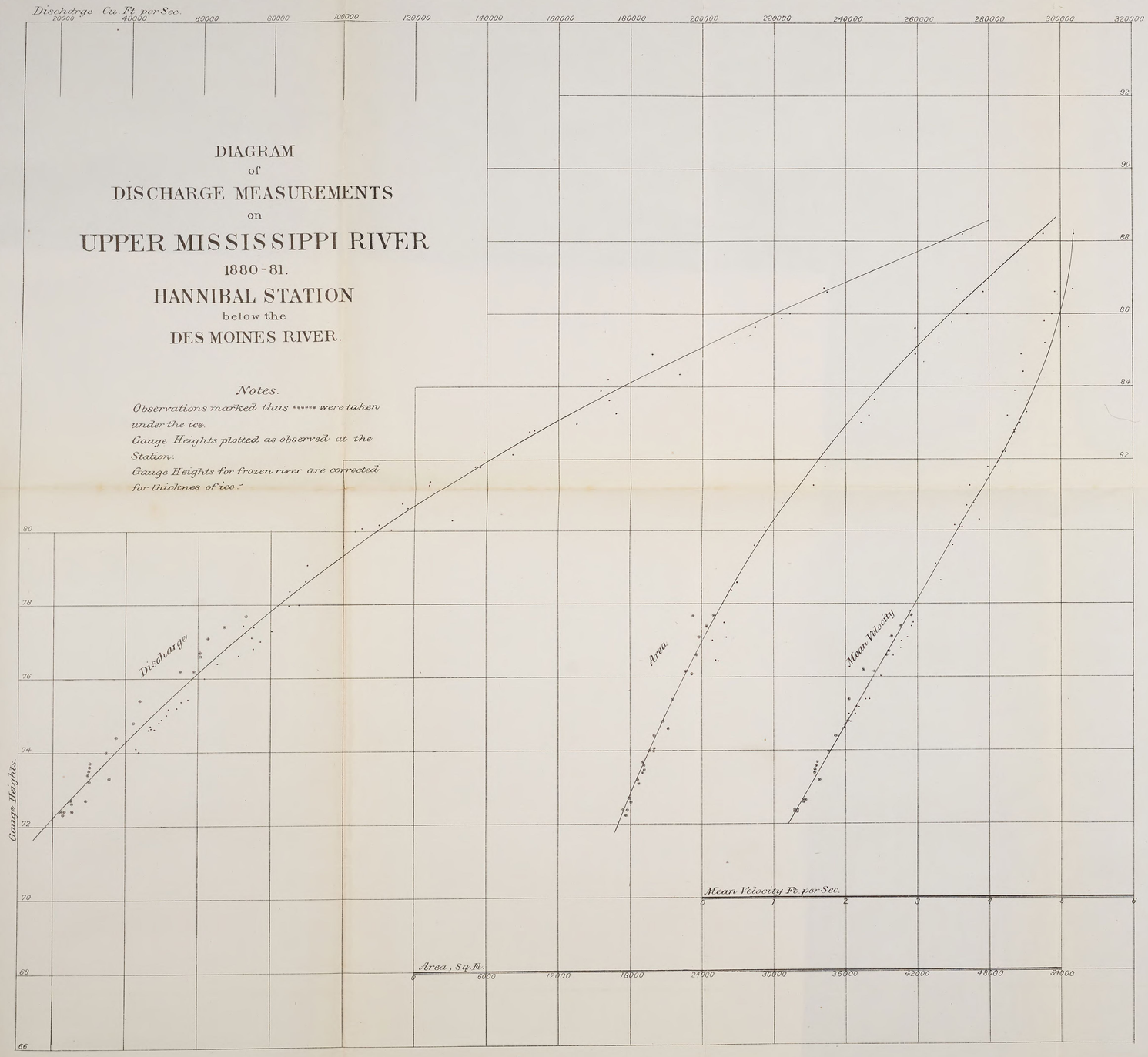


DIAGRAM
showing location of discharge section.
HANNIBAL.

* *Indicates position of slope guages.*

0 500 1000 Ft.

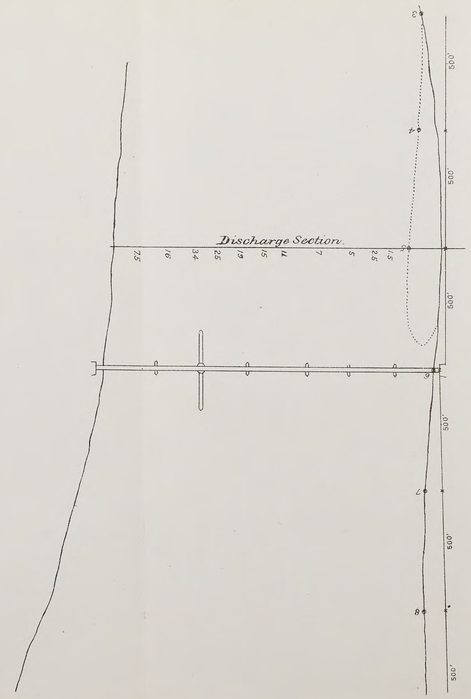


DIAGRAM
of
DISCHARGE MEASUREMENTS
on
UPPER MISSISSIPPI RIVER
1880-81.
GRAFTON STATION
below the
ILLINOIS RIVER

Notes:
*Observations under ice indicated thus ****.*
For frozen river, gauge heights are corrected for thickness of ice.

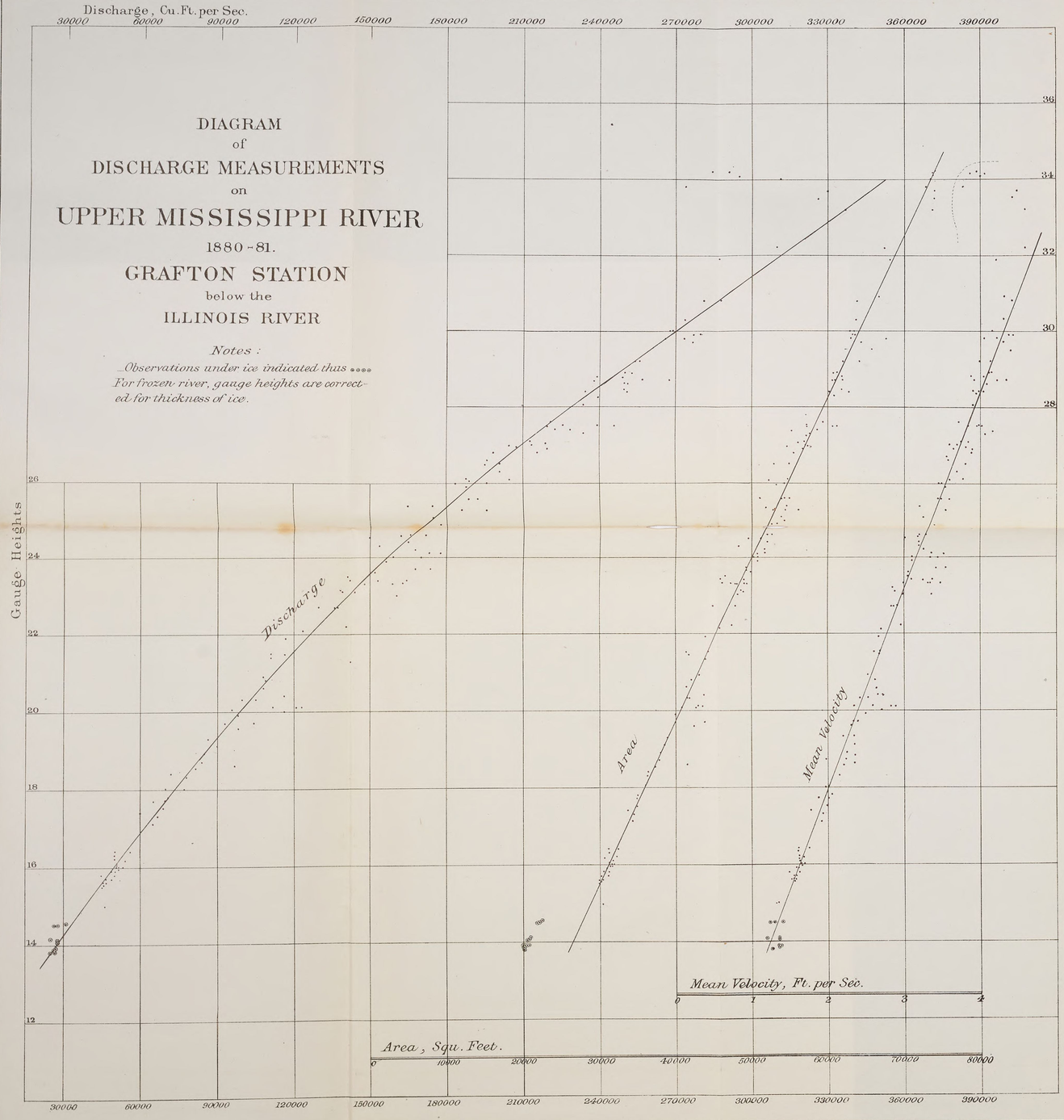


DIAGRAM
showing location of
discharge section.
GRAFTON

Note.
This station is about 20 miles above the mouth of the Missouri River.



DIAGRAM
of
DISCHARGE MEASUREMENTS
on
UPPER MISSISSIPPI RIVER
1880-81.
ST. LOUIS STATION
below the
MISSOURI RIVER.

Notes.

Observations marked thus ••••••• were taken under the ice.

Points marked thus × are for Ice Cake Obs.

Points marked thus ∿ are Mean Velocities of Total River.

Gauge Heights plotted as observed at the Sta. For frozen river Gauge Heights are not corrected for thickness of ice.

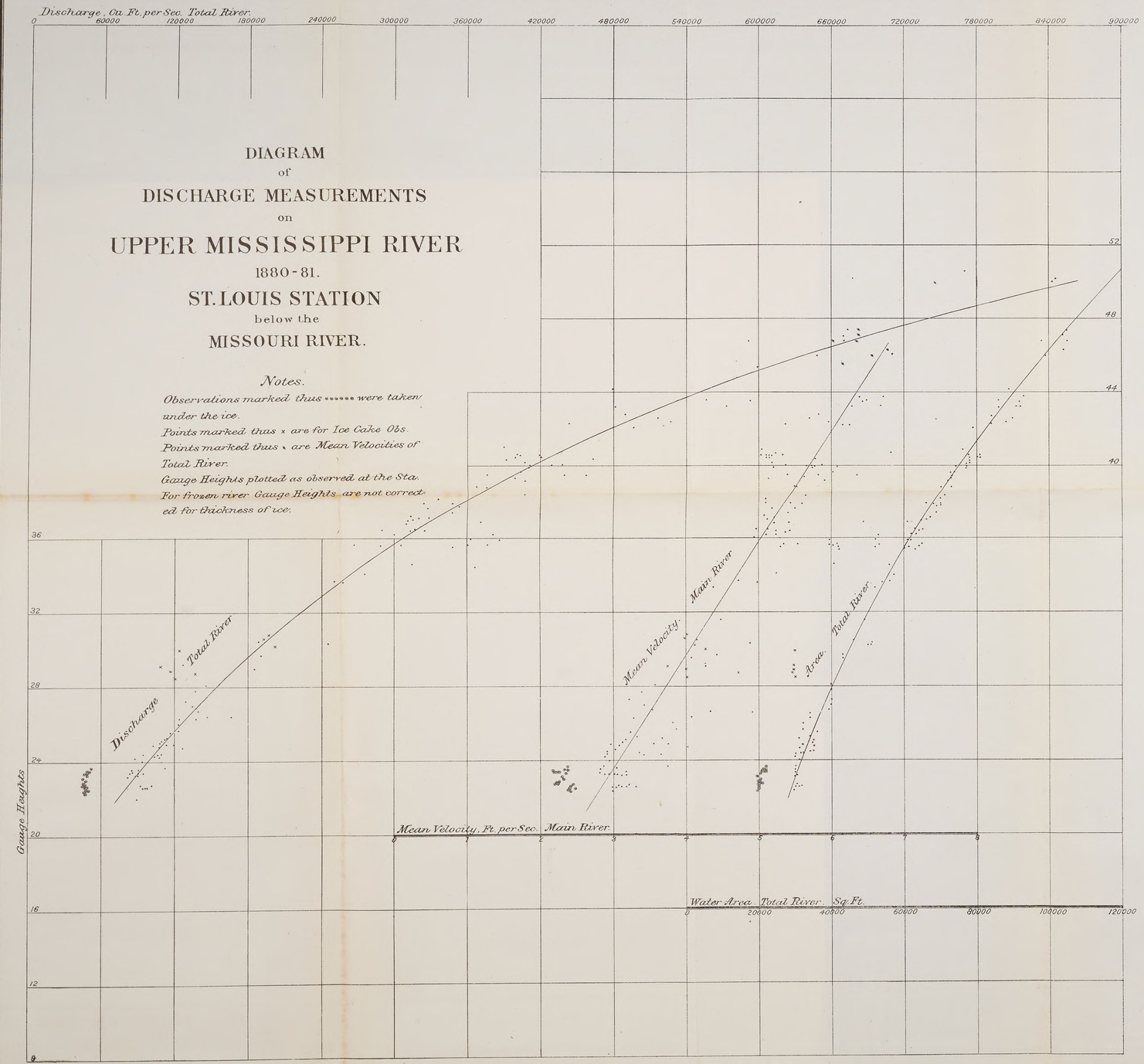
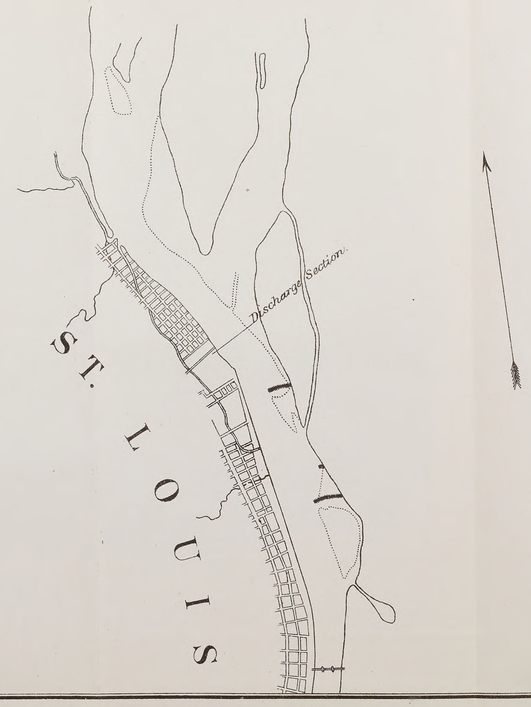


DIAGRAM
showing location of discharge section.
ST. LOUIS





REPORT OF MISS. RIVER COMMISSION. 1882.

Stone Line Sections

Saint Louis Landing Ark. to Port Anderson Miss.

Prepared to accompany the Report of the Mississippi River Commission.

APPENDIX G. Plate 1.

Left Bank

Right Bank

Elevations referred to Memphis Datum

St. Louis Ldg

Stone Line No. 36

Sunflower Ldg

Island No. 66

Stone Line No. 37

Left Bank

Right Bank

Island No. 68

Stone Line No. 40

Levee

St. John's

Stone Line No. 41

Mallowes

Cypress swamp

Stone Line No. 38

Pushmataha

Stone Line No. 39

Island No. 69

Stone Line No. 42

Warfield

Stone Line No. 43

Elevations referred to Memphis Datum

Left Bank

Right Bank

Stone Line Nº 44

Stone Line Nº 45

Stone Line Nº 46

Stone Line Nº 47

Left Bank

Right Bank

Stone Line Nº 48

Stone Line Nº 49

Stone Line Nº 50

Stone Line Nº 51

Elevations referred to Memphis Datum

Left Bank

Right Bank

Stone Line No 52

Stone Line No 53

Left Bank

Right Bank

Stone Line No 55

Stone Line No 56

Left Bank

Right Bank

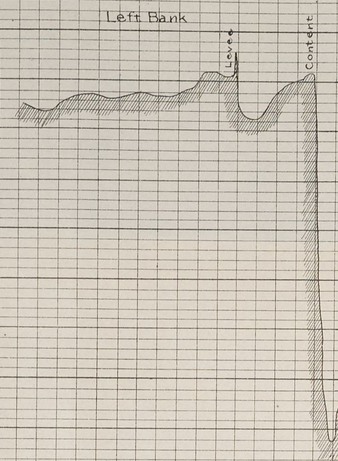
Left Bank

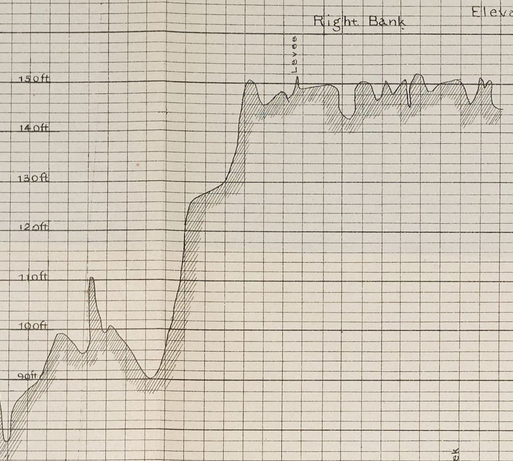
Stone Line No 54

Stone Line No 58

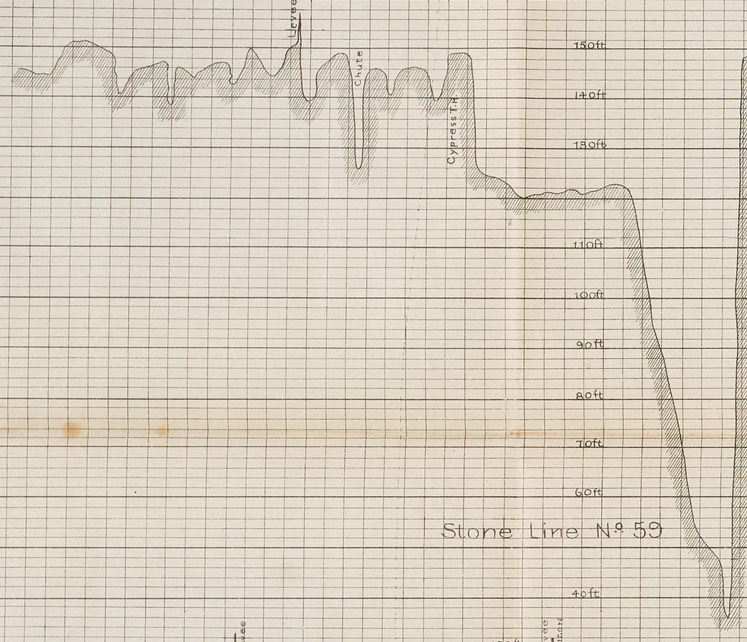
Elevations referred to Memphis Datum

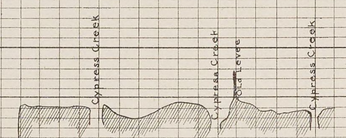
Stone Line No 57



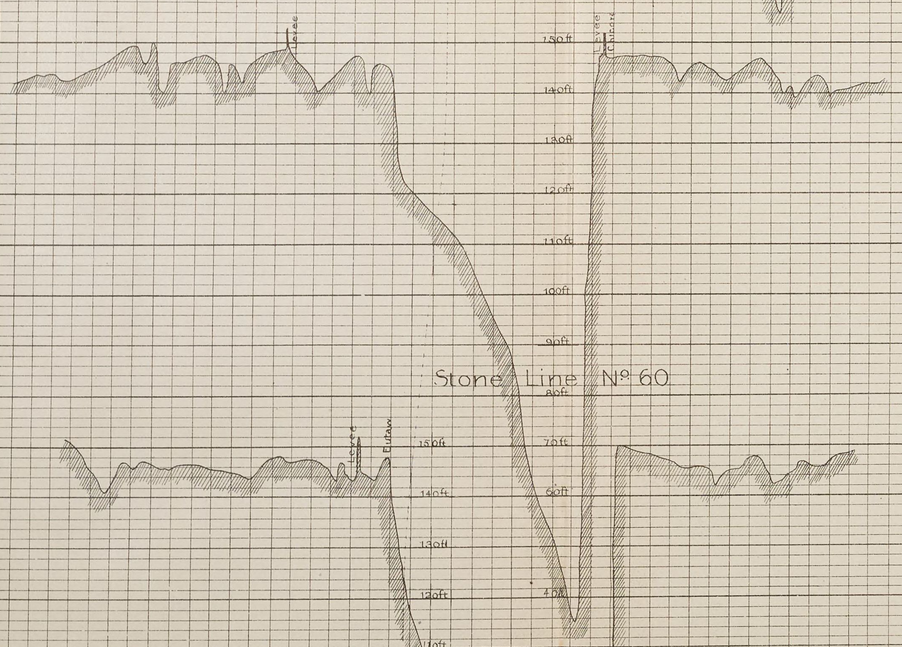


Stone Line No 59

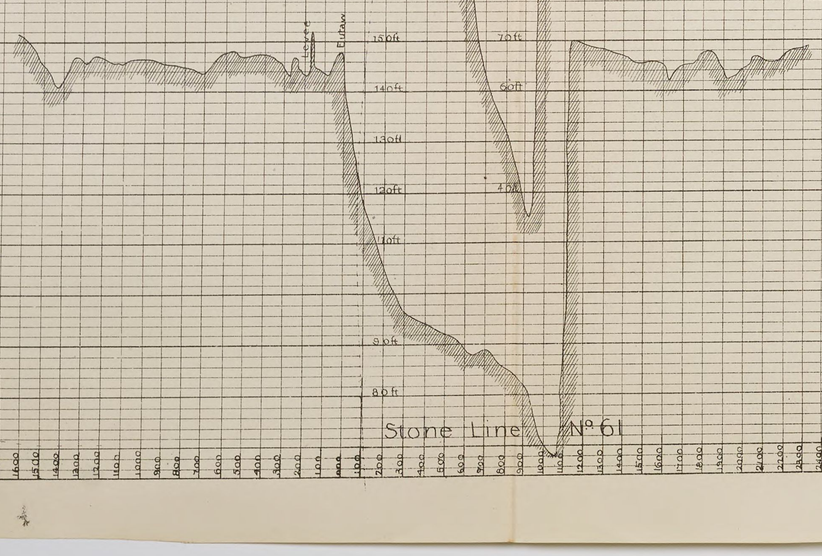


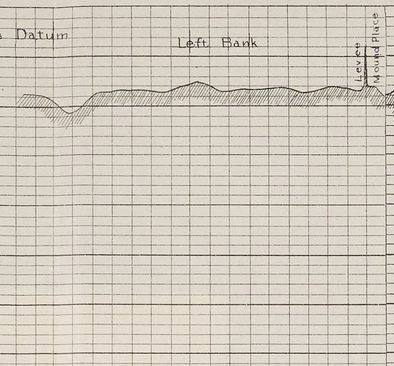


Stone Line No 60

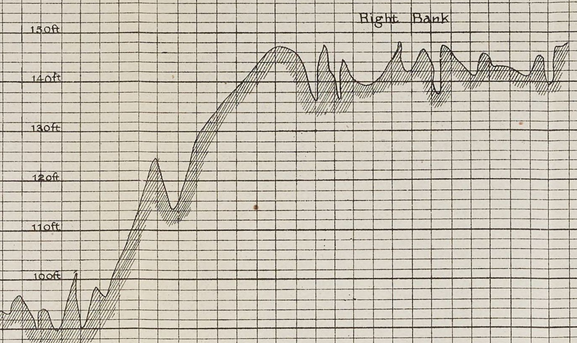


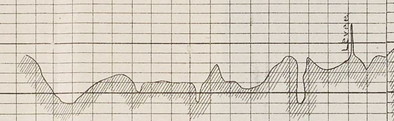
Stone Line No 61



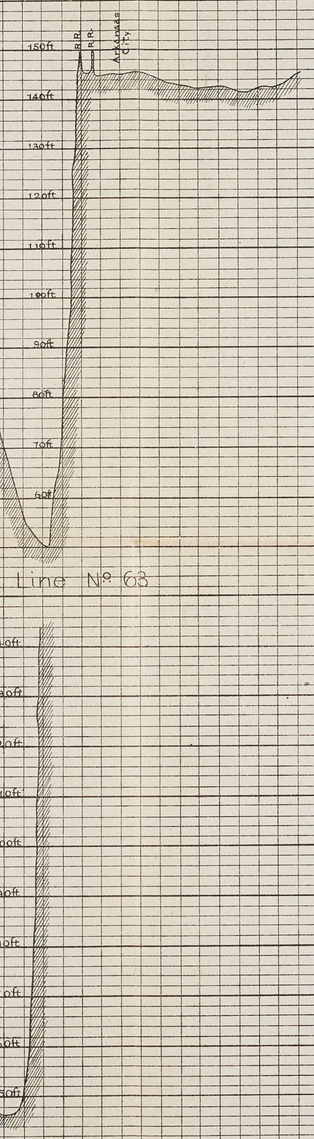


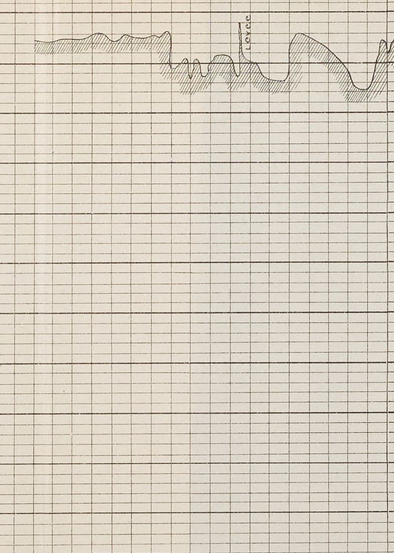
Stone Line No 62



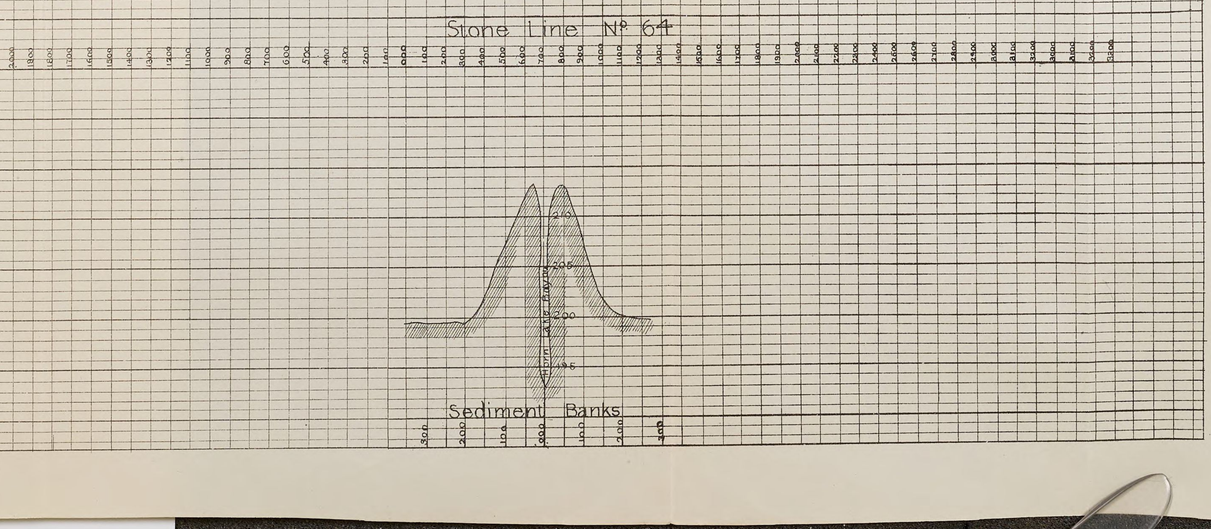


Stone Line No 63





Stone Line No 64



Sediment Banks



TOPOGRAPHICAL SURVEY

Made During Season of 1881 & 1882 by Party in Charge of

J. A. Ockerson U.S. Asst. Engr.

SCALE = 1: 225,000

STATUTE MILES

9 8 7 6 5 4 3 2 1 0 10 20 30

Daniel's Pt.

ARKANSAS

Ashport Bar

Ashport

Johnson's Ldg.
(Gold Dust)

Mud Bayou

Fletcher's Ldg.

Bar

Elmot Bar

Elmot

Island No. 30

PLUM POINT

Osceola Bar

OSCEOLA

Driver's Ldg.

Bullerton T. H.

Petty's Ldg.

TENNESSEE

Yankee Bar

Craighead Pt.

Cold Cr.

Ft. Pillow

ASHPORT

MAP OF

PLUM POINT REACH,

MISSISSIPPI RIVER.

November, 1882.

To accompany Report of

Capt. John G.D.Knight,

Corps of Engrs. U.S.A.

Scale of Feet:

0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000

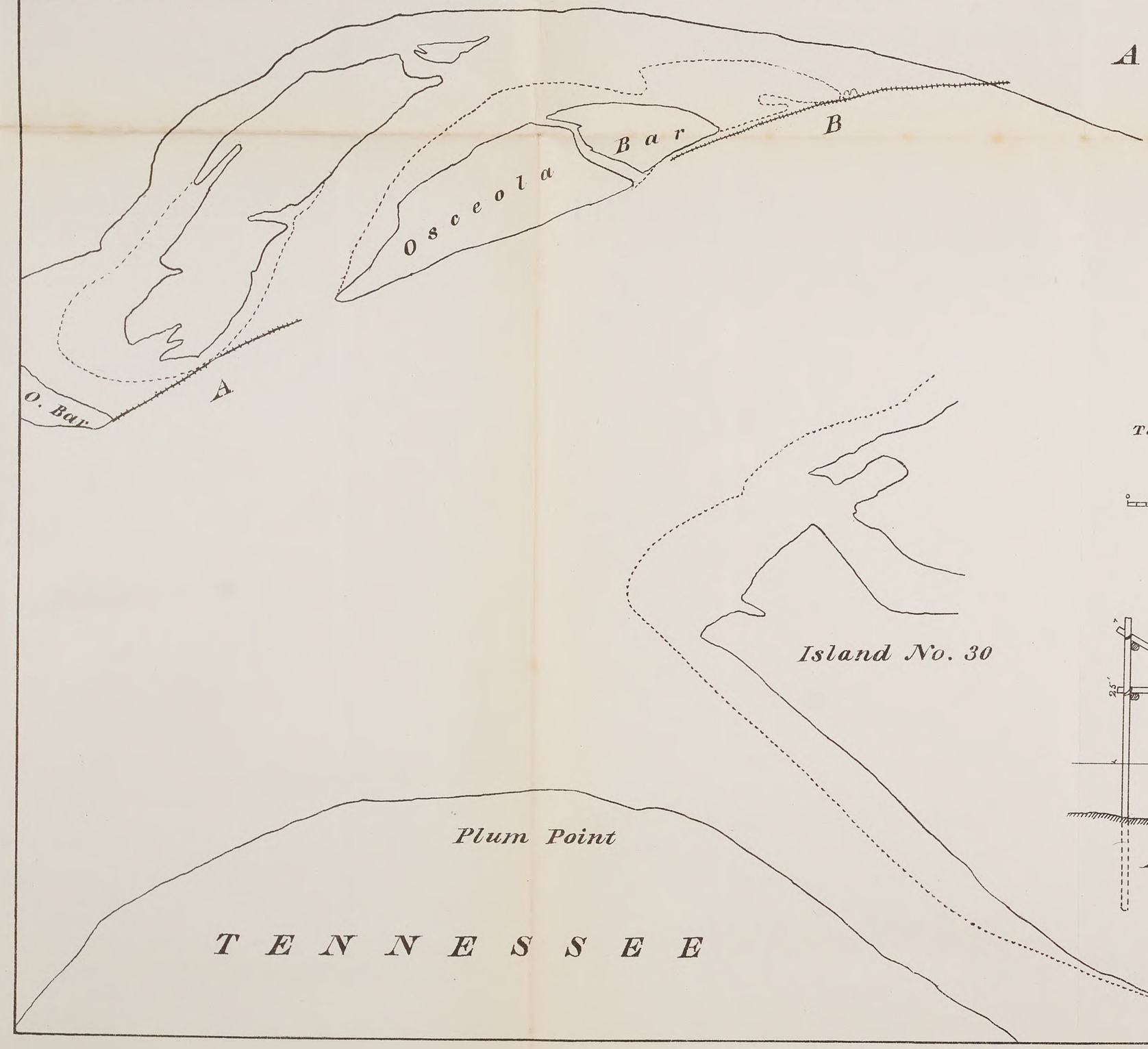
Bluff Banks ————

Bars, at 5 ft. Stage .....

Channel Line —..—..—..—..

O. of Gauge, low water of 1879.

Proposed Dykes ----------



WORKS AT
OSCEOLA BAR,
MISSISSIPPI RIVER.

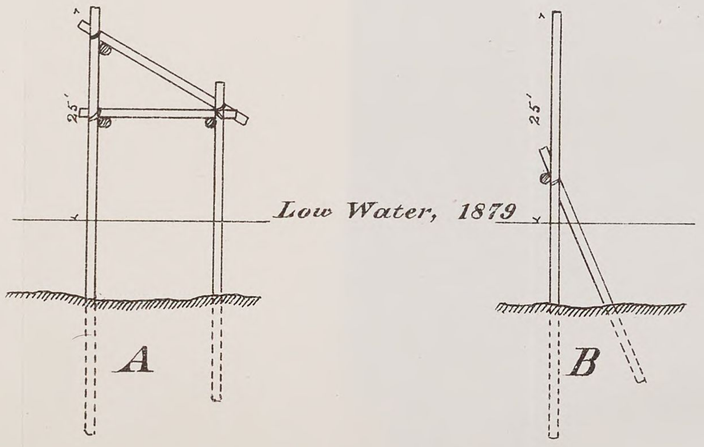
Dec. 1st. 1882.

To accompany Report of Capt. John G.D.Knight, Corps of Engrs. U.S.A.

Scale of Feet:

0 500 1000 2000 3000 4000 5000

Pile Dyke ++++++++++



Elevations of Pile Bents.

A R K A N S A S

Driver's Ldg.

Osceola Bar

Bullerton Towhead

T E N N E S S E E

WORKS AT
BULLERTON TOWHEAD,
MISSISSIPPI RIVER.

Dec. 1st. 1882.

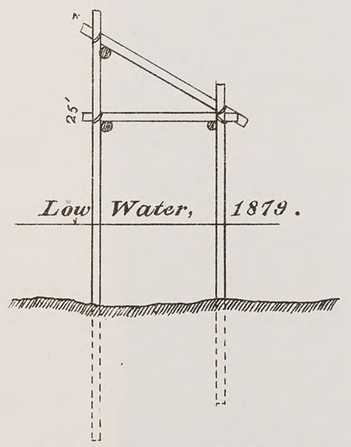
To accompany Report of Capt. John G.D.Knight, Corps of Engrs., U.S.A.

Scale of Feet:

0 500 1000 2000 3000 4000 5000

Pile Dyke

Mat



Elevation of Pile Bent.

WORKS AT HEAD OF ELMOT CHUTE, MISSISSIPPI RIVER.

Dec. 1st. 1882.

To accompany Report of Capt. John G.D. Knight, Corps of Engrs., U.S.A.

Scale of Feet:

0 500 1000 2000 3000 4000 5000

Pile Dyke ++++++++++++++++

ARKANSAS

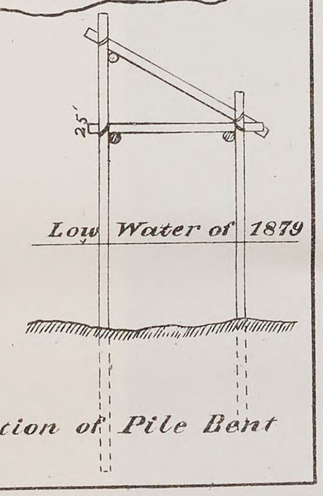
Mill Bayou

Ashport Bar

Elmot Bar

Johnson's Ldg. (Gold Dust)

TENNESSEE



Elevation of Pile Bent

A R K A N S A S

Daniel's Point

A s h p o r t B a r

WORKS AT
ASHPORT, TENN.,
MISSISSIPPI RIVER.

Dec. 1st. 1882.

To accompany Report of Capt. John G.D.Knight, Corps of Engrs., U.S.A.

Scale of Feet:

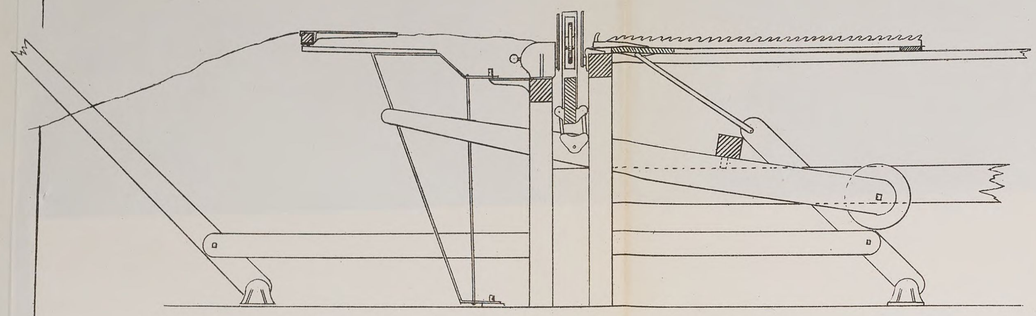
0 500 1000 2000 3000 4000 5000

Mat, 150 ft. wide,

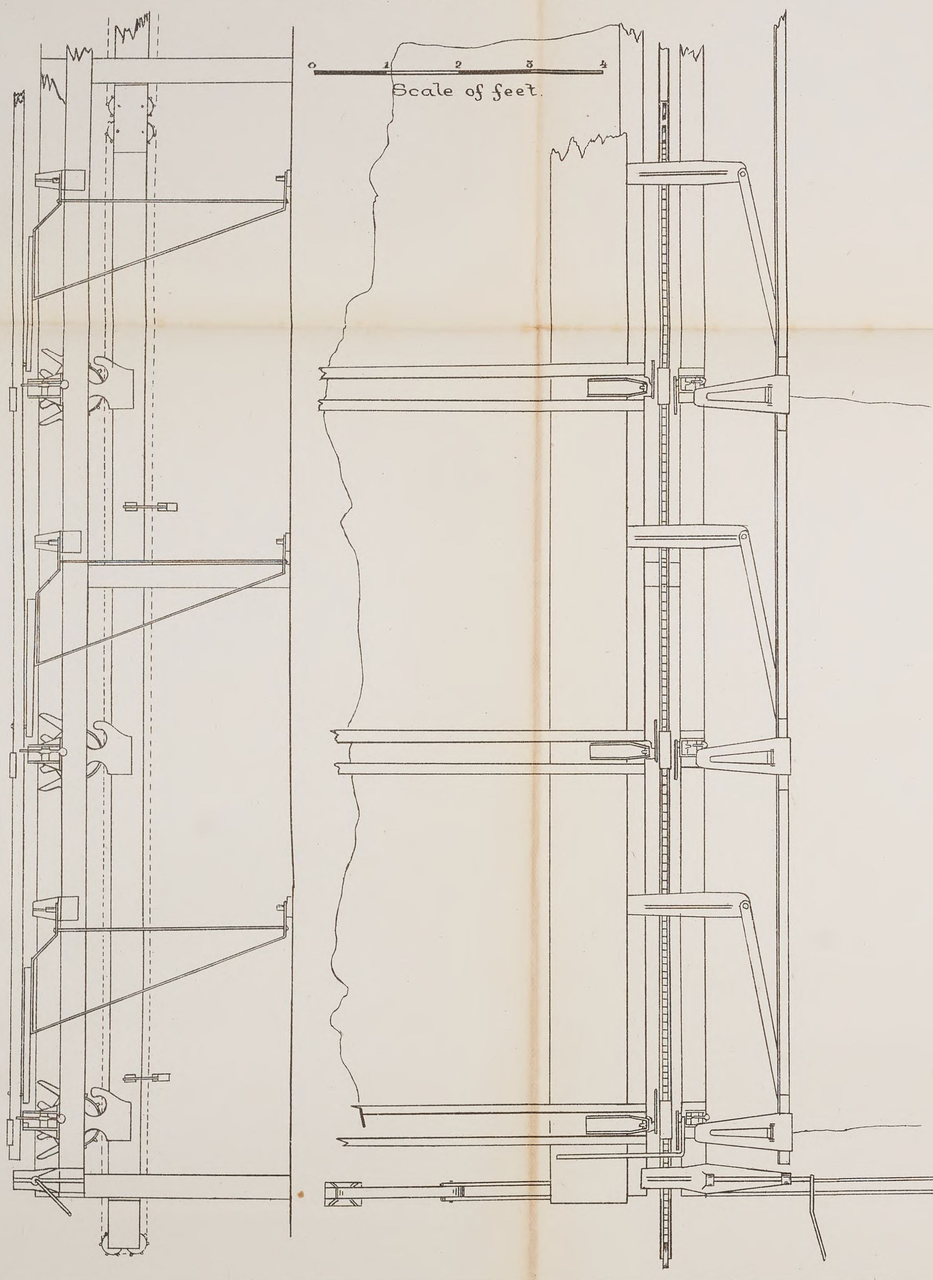
Island No. 27

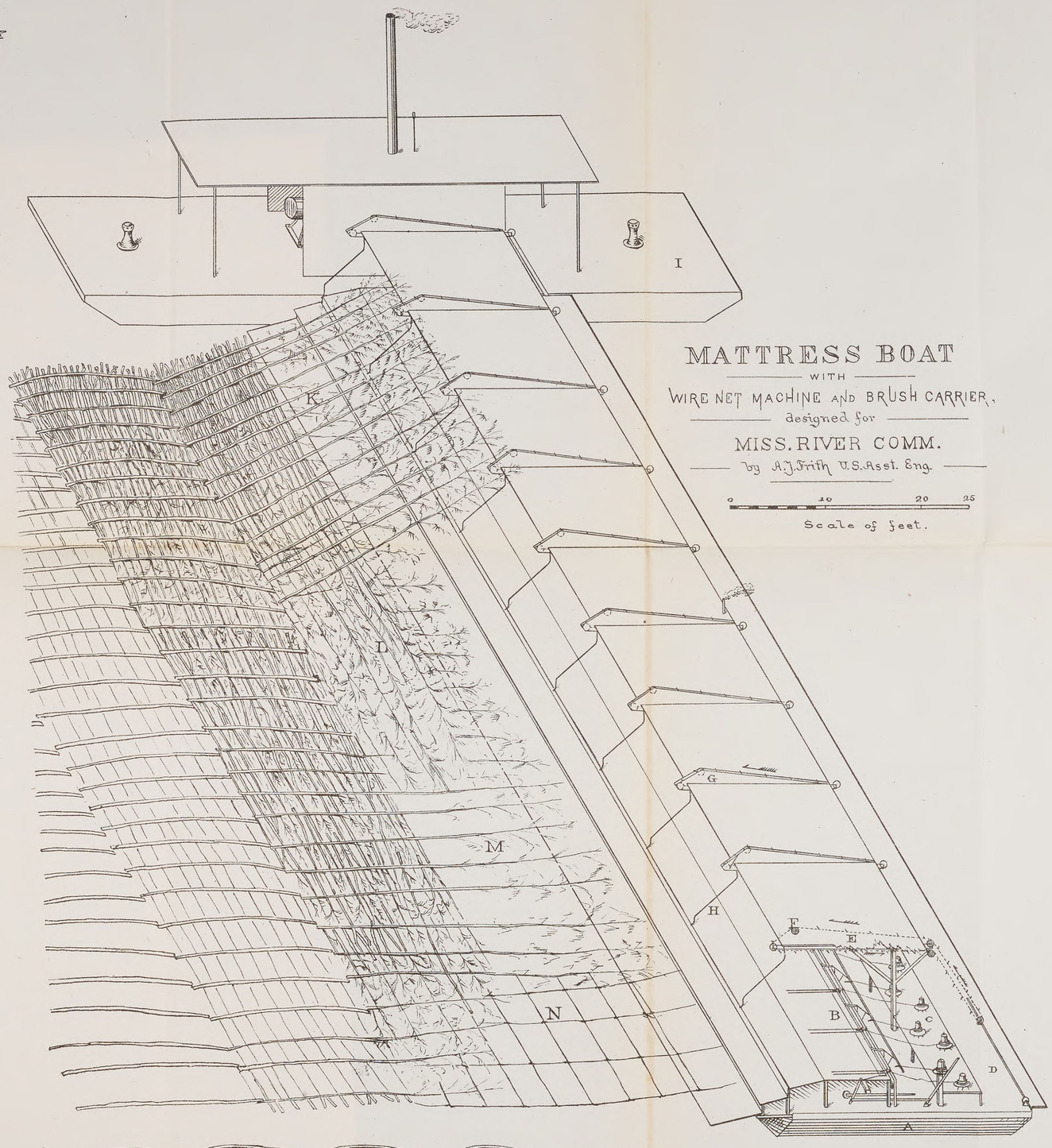
ASHPORT

T E N N E S S E E



WIRE NET MACHINE





MATTRESS BOAT

WITH

WIRE NET MACHINE AND BRUSH CARRIER,

designed for

MISS. RIVER COMM.

by A.J. Frith U.S. Asst. Eng.

0 10 20 25

Scale of feet.



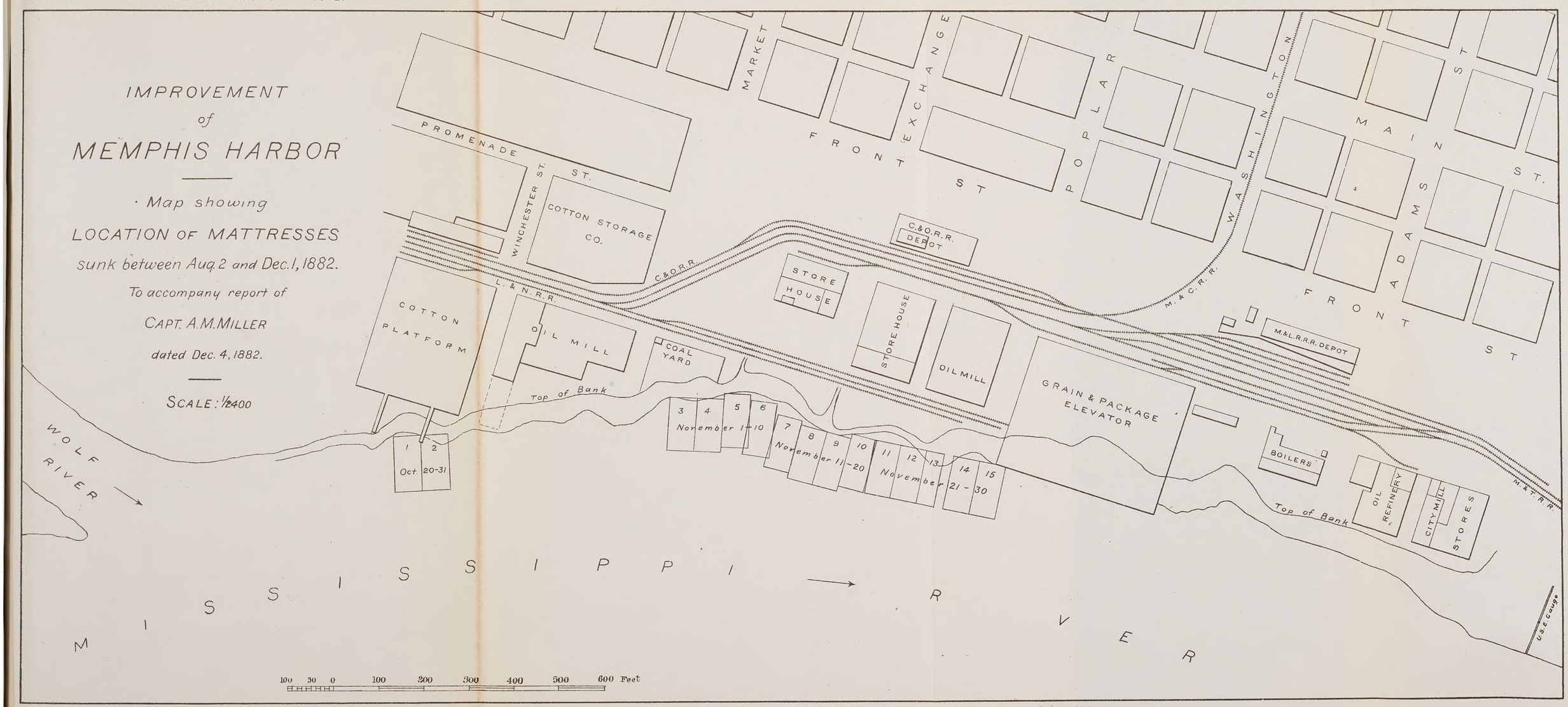
SECTION OF MATTRESS.

IMPROVEMENT of MEMPHIS HARBOR

· Map showing LOCATION OF MATTRESSES sunk between Aug. 2 and Dec. 1, 1882.

To accompany report of CAPT. A.M. MILLER dated Dec. 4, 1882.

SCALE: 1/2400



MISSISSIPPI RIVER COMMISSION.

I.M.R. LAKE PROVIDENCE, LA.

Capt. W.L. Marshall, Corps of Engrs. U.S.A. in charge.

CHART OF

LAKE PROVIDENCE REACH.

Shore line Survey executed in Oct. & Nov '81.

Hydrography executed in April, '82.

Wm T. Blunt, U.S. Asst. Engr.

Legend.

Survey based on Triangulation of the U.S.C. & G. Survey.
Soundings were taken at a stage of water
35ft. on L.P. Gauge, and are reduced
to a stage reading -1.5ft. on Gauge.
------ *Represents water line at 15ft. on L.P. Gauge.*
-·-·-·- " " " " 7 " " " "
..... " " " " 4.5 " " " "
——— " *Pile dikes built*

ARKANSAS

LOUISIANA

Carolina Ldg.

SARAH'S ISLAND

Duncansby Ldg.

Skipwith's

Mayersville

MAYERSVILLE TD. No 93

STACK ID. No 94

LAKE PROVIDENCE

Ajax Bar

ISLAND No 95

POINT LOOKOUT

Tallula

4000 3000 2000 1000 0 1000 Meters

18000 15000 12000 9000 6000 3000 0 Feet

3 2 1 0 ¼ ½ ¾ 1 Miles

MISSISSIPPI RIVER COMMISSION

I.M.R. LAKE PROVIDENCE, LA.

Capt. W.L. Marshall, Corps of Engrs. U.S.A.
in charge.

SKETCH OF

LAKE PROVIDENCE REACH.

Hydrography executed in Oct. 1882

Wm. T. Blunt, U.S. Asst. Engr.

Scale, $\frac{1}{60,000}$

——Legend.——

Soundings were taken at a Stage of water 8.5 ft. on L.P. Gauge and are reduced to a stage reading -1.5 on Gauge

------ *Represents water line at -9.5 ft on L.P. Gauge, or limits of 8 ft channel at stage -1.5 ft.*

-·-·- *Represents proposed limits of Regularized River, as approved Sept. 16th, 1882. Width 3000. ft.*

——— *Represents pile dikes built at time of Survey.*

4000 3000 2000 1000 0 1000 Meters

18000 15000 12000 9000 6000 3000 0 Feet

3 2 1 0 ¼ ½ ¾ 1 Miles

ARKANSAS

MISSISSIPPI

LOUISIANA

LAKE PROVIDENCE

Carolina Ldg.

Ashton Ldg.

Pilchers Pt.

Shore Oct. 1881

Shore Oct. 1882

Duncanby

Skipwith's

Mayersville

STACK III
No 94

Ajax Bar

ISLAND No 95

Point Lookout

SKETCH OF PILE DIKES

Lake Providence Reach, La.

Dec 1, 1882.

—NOTE—
CROSS DIKES HAVE NO WIDE MAT IN FRONT
LONGITUDINAL DIKES HAVE FOOTMATS BUT NO SCREENS

SCALE = 6 0. 1 2. 3. 4. 5. 6 Ft.

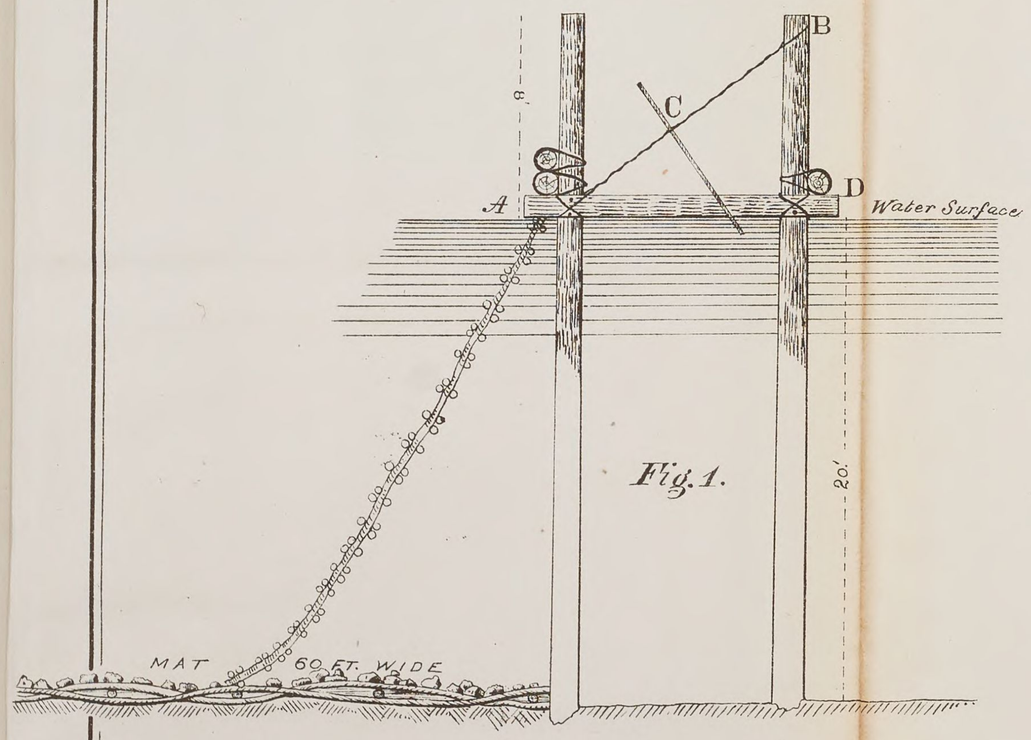


Fig. 1.

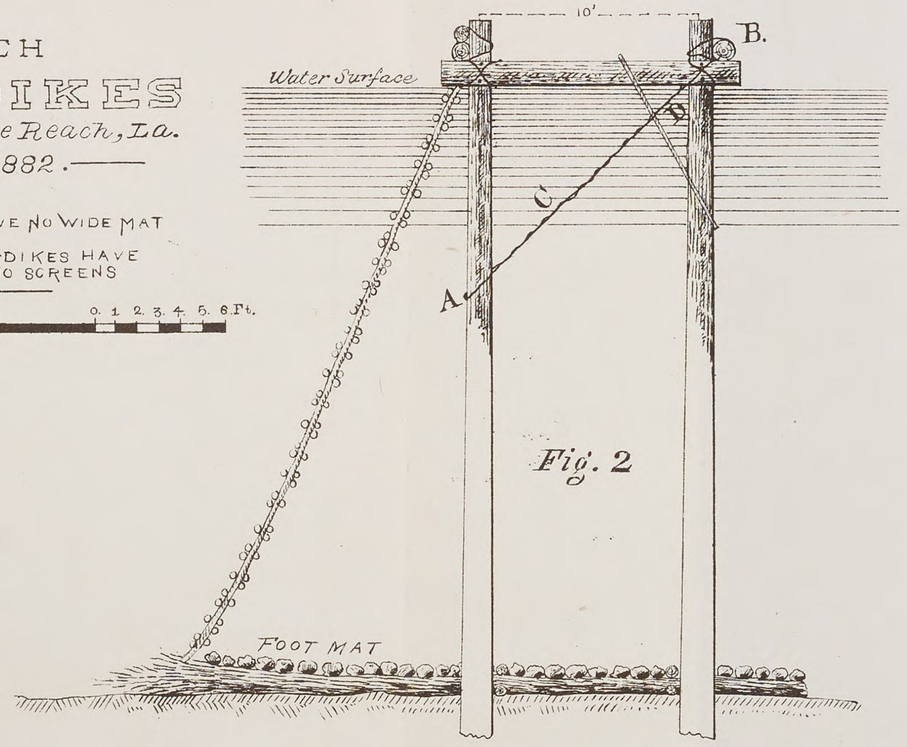
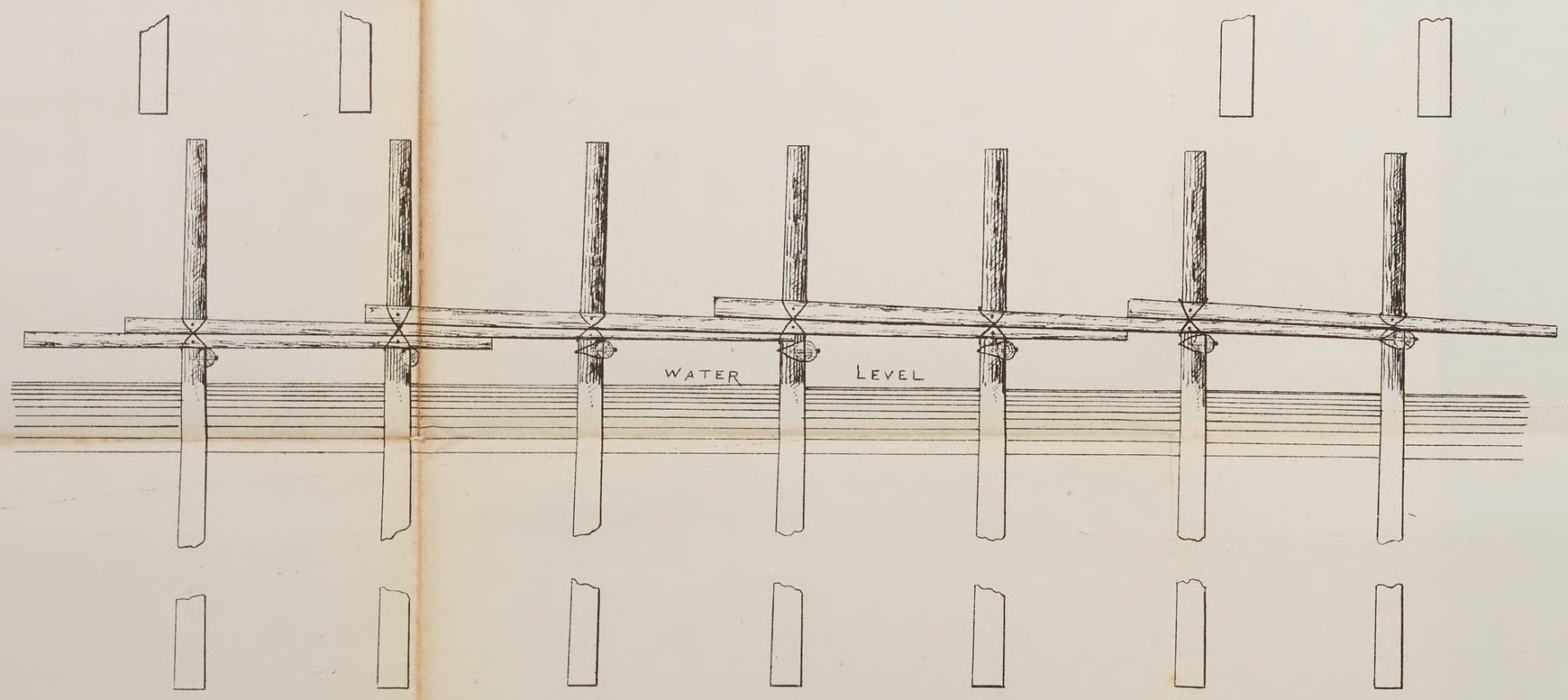
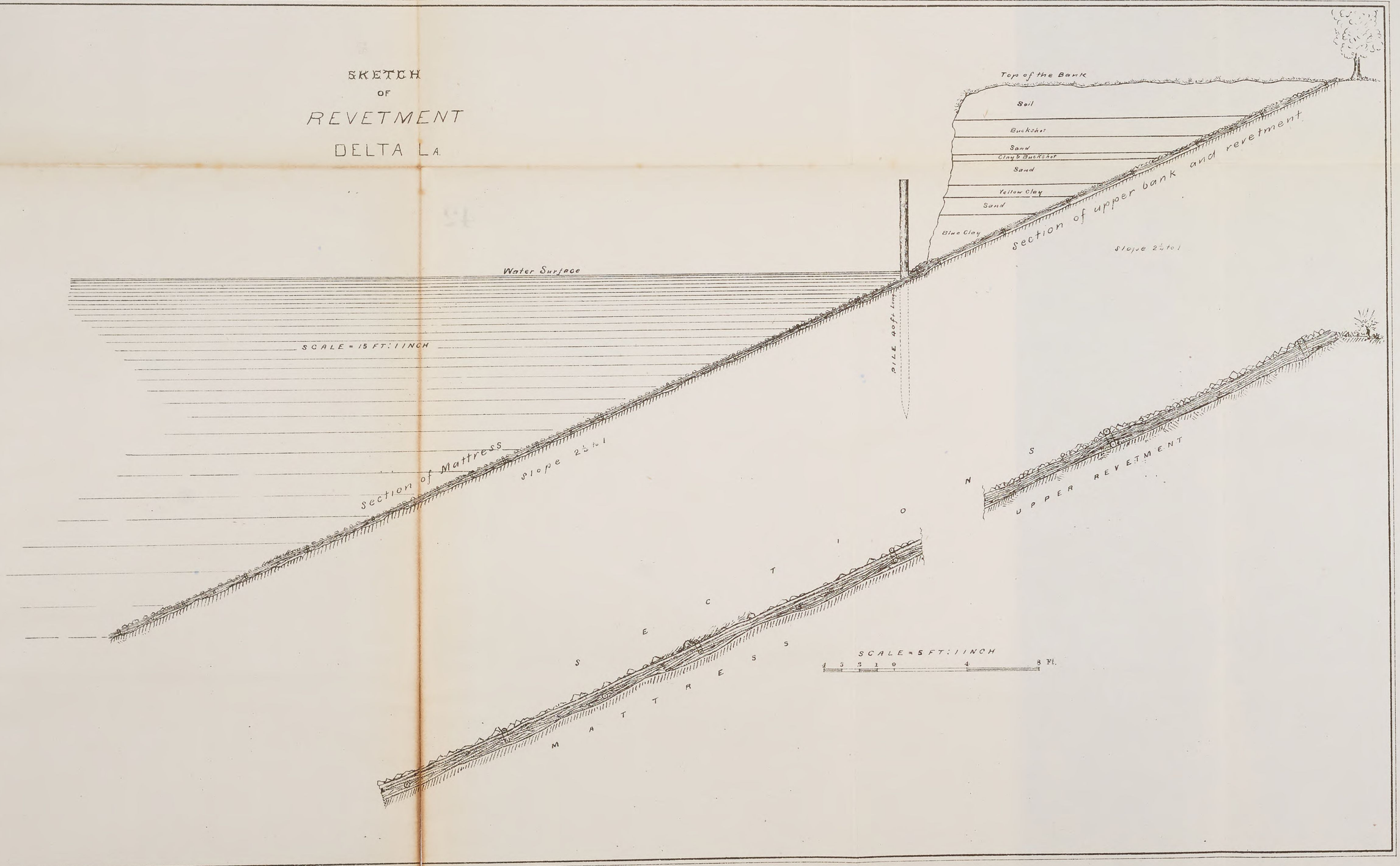


Fig. 2



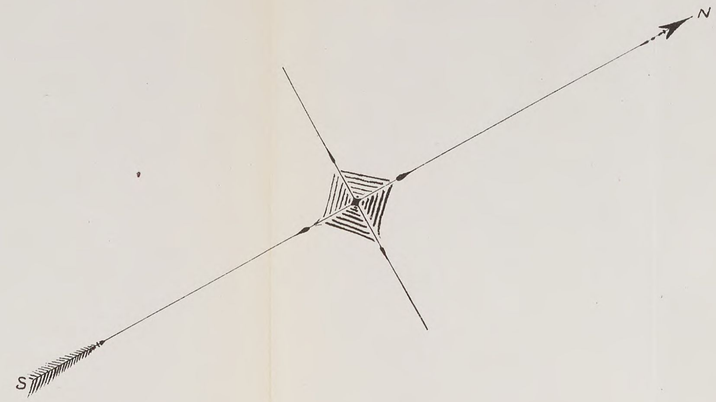
SKETCH OF REVETMENT DELTA LA.



MAP
OF
VICKSBURG HARBOR
AND
MISSISSIPPI RIVER IN THAT VICINITY
Showing Position and Extent of Revetment on
DELTA POINT LA
November 30th
1882

Scale of Feet
12 RH 9 8 7 6 5 4 3 2 1 0 1200 2400 3600 Ft.

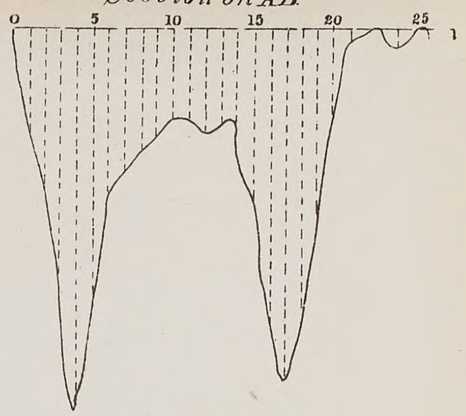
Note
Figures represent soundings made August 1882 and referred to the zero of the gauge
Black spaces thus ■ represent revetment built 1882
Spaces thus ▨ represent revetment built in previous years



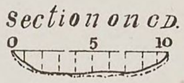
SAND BAR
DELTA POINT
Kings Point
Heavy Timber
OLD BANK
Cotton woods
Office and Quarters Govt Works
Wharf Boat
V.S.&P.R.R.
OLD RIVER BANK
Willow camp
Low Water 1882
MISSISSIPPI RIVER
MUD BAR
Cottonwoods
CENTENNIAL LAKE
DESOTO ISLAND
Willows
Proposed Canal
Ryans Mill
Cemetery
Depot
Mint
Mint Bayou
NATIONAL CEMETERY
BLUFFS
V.S.&M.R.R.
VICKSBURG

SKETCH
— of —
Sections in & near
CUBITTS GAP

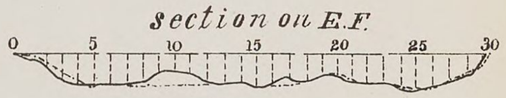
Section on AB



Section on CD.



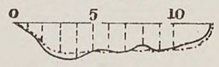
Section on E.F.



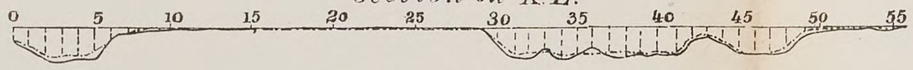
Section on G.H.



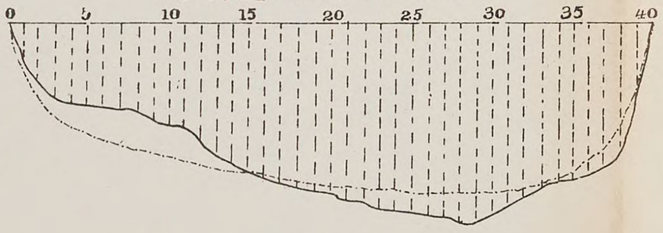
Section on IJ.



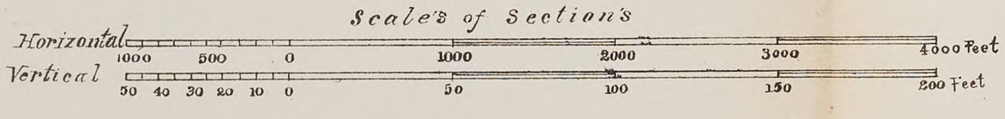
Section on K.L.



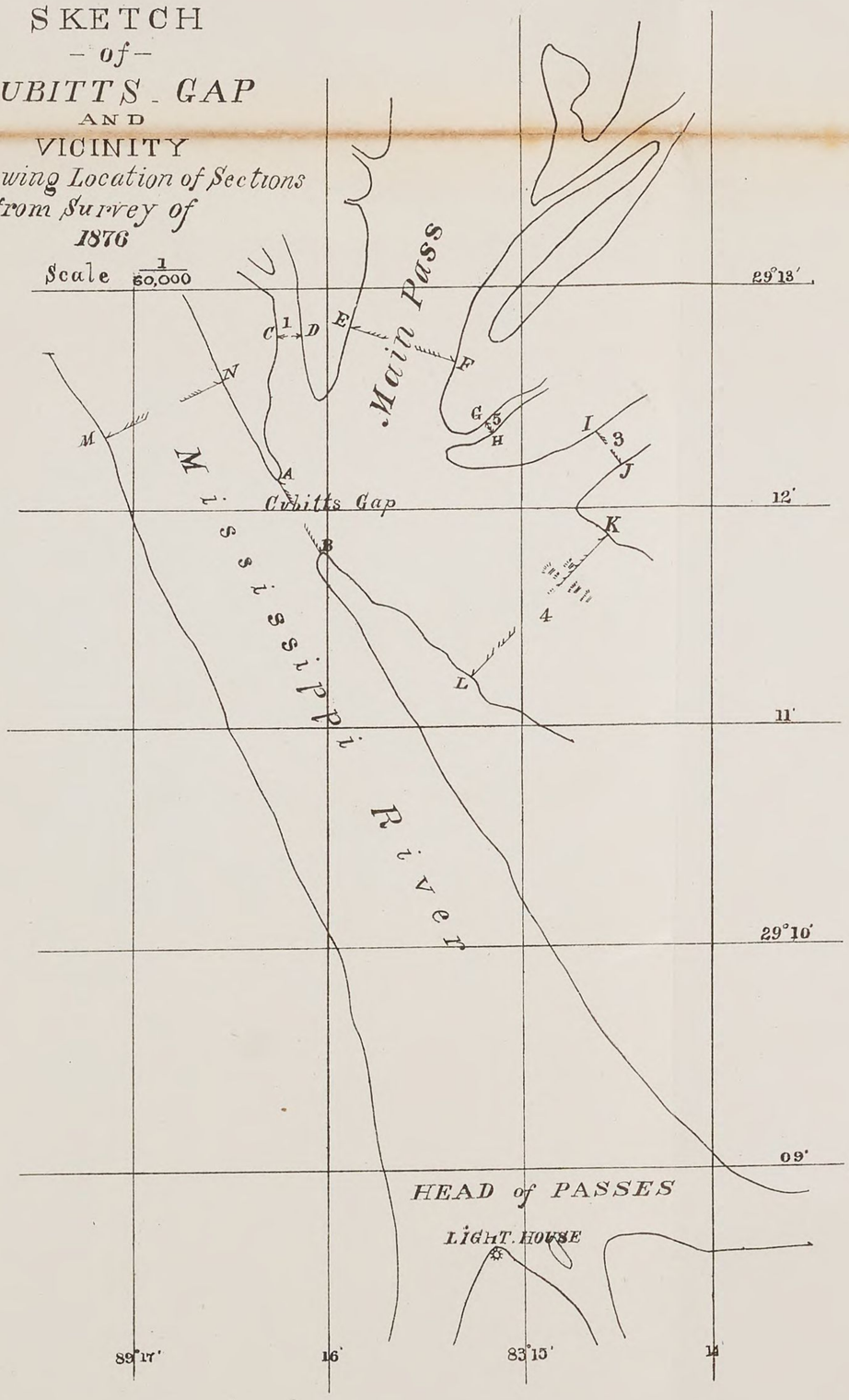
River Section M.N.



Scales of Sections



SKETCH
— of —
CUBITTS GAP
AND
VICINITY
Showing Location of Sections from Survey of
1876
Scale 1/60,000



Compiled by H. L Marindin Assist., to accompany Report of Prof. H. Mitchell.

Nov. 17th 1876

MISSISSIPPI RIVER, LOUISIANA.

Sketch of Areas

Covered by Comparisons

of

Surveys in

1866, 1872 - 75 - 76 & 77

Scale $\frac{1}{50000}$.

